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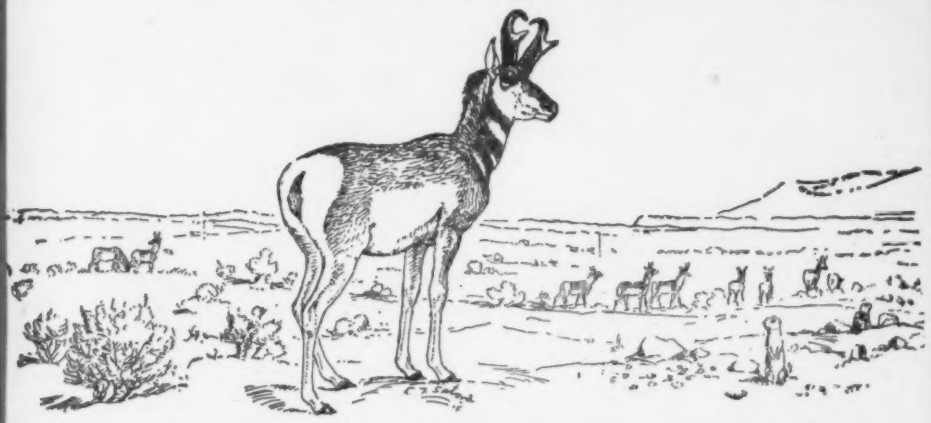

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LINEAR AND COLORIMETRIC MEASUREMENTS OF SMALL MAMMALS

BY FRANCIS B. SUMNER

[*Plates 16–19*]

In a recent paper in this journal (Sumner, 1926), I expressed the immediate intention of devoting a special article to an account of the methods employed by me in measuring various characters of *Peromyscus* and other small rodents. This has long seemed desirable for several reasons: (1) In order to make clearer the exact nature of the characters with which I have been dealing in my studies of variation and heredity, during the past thirteen years; (2) to enable other investigators who enter this field to obtain results comparable with mine; (3) to contribute something toward a much desired standardization of the technique of measurement, particularly as regard color.[1]

LINEAR MEASUREMENTS

GENERAL

A long-continued, intensive study of racial and individual differences, chiefly in species of the genus *Peromyscus*, has impressed me with the inadequacy of the methods of measurement commonly employed, even by highly competent mammalogists. Where small species are concerned, the results at best can only be regarded as rather rough approximations. Data from series which are taken at different times,

[1] Brief, incidental accounts of these methods have been included in various papers by myself and collaborators (see "Literature Cited").

under different conditions, and especially from series which are collected and measured by different persons, can not be regarded as comparable with one another. At least, they can not be depended upon to reveal certain quantitative relations which may be highly important in studies of variation or heredity.

This relative inexactness of the measurements which are commonly made of small mammals may be attributed to three chief causes. (1) The condition of the material measured is far from uniform. Specimens may be freshly killed, rigid in rigor mortis, distorted from injury, relaxed in putrefaction, or more or less dried out. (2) The methods of measurements are not sufficiently refined. The manipulation is commonly rather crude, and readings are made to the nearest millimeter (or in fractions of an inch), in cases where tenths of a millimeter would be desirable. (3) There is a decided lack of uniformity in the details of the procedure adopted by different and equally competent individuals; in other words, there is a considerable "personal equation."[2]

This may seem like a rather serious indictment of current practices, and it may be resented by some taxonomic experts and experienced collectors, particularly as it comes from one who has never so much as named a subspecies. But I think that most mammalogists know at heart that the criticism is justified, and in any case I shall proceed to give evidence of its truth.

I must first state, however, that the inadequacy of which I speak probably applies chiefly to small species. A discrepancy of half a millimeter in foot or ear length would be trivial in measuring a jack rabbit, but it becomes serious when one deals with a mouse or shrew.

That standardized, small-scale measurements may reveal important facts which are overlooked by observers who do not employ them is well illustrated by the failure of previous students (at least so far as I know) to recognize a sexual difference in the foot-length of mice. This was long since recorded by me rather doubtfully for albinic *Mus musculus* (Sumner, 1915a), and was later detected with certainty in practically every large series of *Peromyscus* which I measured, belonging to several species and a considerable number of subspecies (1920, 1926, and numerous unpublished data). Males were found to have a slightly greater mean foot-length than females, when individuals of the same size were compared in sufficient numbers, or when both series

[2] Merriam, 1889, Anthony, 1925, and doubtless others have published illustrated instructions for measuring the body, tail and foot of small mammals. Merriam, more than a generation ago, used a caliper (though not one of modern type); Anthony apparently does not do so now.

were reduced to a standard body length. This mean difference is about 0.4 mm. in the *P. polionotus* group.

To test the question of "personal equation," I obtained the coöperation of two unusually competent mammalogists. Both are men whose names are doubtless known to almost every reader of this journal; and they are, as it happens, associated together in the same museum.

Ten specimens of *Peromyscus maniculatus gambelii* were killed and measured, first by me, and then by the other two observers, whom I shall call A and B. The measurements were repeated on the following day by the same individuals in reverse order.

In taking my own measurements I employed the system to be described below (p. 182). A and B used a metric rule for the body and tail measurements, and a vernier caliper for the feet and ears. It

TABLE 1

	OBSERVER	TOTAL LENGTH	TAIL	BODY (TOTAL—TAIL)	FOOT	EAR
First day	S (Sumner)	164.7	74.9	89.8	19.62	16.52
	A	156.3	70.9	85.4	19.65	16.20
	B	158.6	70.2	88.4	19.70	16.31
Second day	S	163.9	74.4	89.5	19.59	16.12
	A	163.7	72.2	91.5	19.30	15.70
	B	164.1	71.1	93.0	20.00	15.94

should be said that in making the measurements of the first day, I dealt with the mice shortly after killing, while the other observers measured them some hours later. This circumstance probably accounts for a *small part* of the difference here shown, but not for all or most of it, as will appear later. In the case of the second day's measurements, the time factor is of no importance. The results are shown in table 1, which gives the mean values for the ten animals measured.

I may summarize the results of this test as follows:

(1) There are considerable individual differences among the corresponding measurements of all three observers, though those of A and B naturally differ less than do those of S from either of the others.

(2) The differences are most pronounced for the body and tail measurements, less so for those of foot and ear. Indeed, the foot measurements on the first day are closely alike for all three observers.

(3) Some of the differences between corresponding figures are very

great, and these become greater still when we refer to the individual entries in the original records. Thus there are several cases in which the tail length of a mouse, as recorded by S, is 6 mm. greater than that recorded by A. From the standpoint of variational studies, this is a huge difference. Even A and B frequently differ by as much as 3 mm. in their measurements of this member.

(4) In the case of both A and B, the corresponding figures for the first and second day differ rather widely in nearly every case. My own figures, on the other hand, agree very closely for the two days, with the exception of those for the ear, which show a mean difference of 0.4 mm.[3]

This relative uniformity in the case of my own measurements is a matter of some interest. Since the series of figures next to be presented indicate that measurements of mice taken on two consecutive days should differ but slightly from one another, it seems reasonable to

TABLE 2

TIME AFTER DEATH	TOTAL	TAIL	BODY	FOOT	EAR
0	166.65	76.95	89.70	20.455	16.950
15 minutes	166.70	76.90	89.80	20.440	16.975
45 minutes	165.85	77.05	88.80	20.395	16.865
2 hours	164 10	75.80	88.30	20.425	16.845

conclude that the rather close agreement of my own two sets of measurements implies a greater degree of accuracy for these last, as compared with those of the other two observers. And since I have no right to regard myself as a more careful observer than either A or B, there remains the alternative explanation that the methods of measurement which I have adopted are more reliable than those customarily employed.[4]

Before considering these methods in detail, I shall give figures showing the extent of the differences which may result from the relative freshness or staleness of the specimens. For testing changes occurring within the first two hours after death, ten mice (*P. m. gambelii*) were killed by ether, each being subjected four times, at appropriate intervals, to the measurements indicated in the preceding table. The measurements were made (1), immediately after death, (2) fifteen minutes, (3) forty-five minutes, and (4) two hours after death. (These intervals

[3] The differences for total length and tail are absolutely greater than this, but relatively much less.

[4] Subject, of course, to the reservation which must always be made when we are dealing with small numbers.

varied somewhat.) By the time of the fourth measurement, and sometimes after forty-five minutes or less, the specimen was in pronounced rigor mortis. It was limbered up by proper manipulation before measurement. The means for the ten individuals are given in table 2.

An inspection of the table warrants us in believing that measurements of mice taken during rigor mortis should be excluded, in cases where precise values are required. On the other hand, measurements made a half-hour or more after death seem to be closely comparable with those taken from freshly killed specimens.

For determining the changes undergone at the end of the first day following death another set of ten mice was used. At the time of measurement, rigor mortis was still perceptible in some specimens, though it had greatly diminished. The bodies and limbs were further limbered by hand, a matter of considerable importance. Following are the mean figures for the ten mice:

TIME AFTER DEATH	TOTAL	TAIL	BODY	FOOT	EAR	WEIGHT
0	165.05	72.75	92.30	19.695	17.175	21.34
26 hours (±)	164.40	72.65	91.75	19.700	16.955	20.97

A slight shrinkage of the body as a whole, including both tail and trunk, is still evident, though this is far less pronounced than in the specimens previously discussed after two hours. In every case, the weight has slighty decreased owing doubtess to evaporation. The foot measurements give almost exactly the same mean figure while the ears have shrunken to the extent of about 0.2 mm.[5]

It has been my custom to include the measurements of occasional animals which have been found dead in the cages, provided that the bodies were sufficiently fresh. The results of the foregoing test seem to justify this procedure. Distinctly stale specimens should, however, never be included among a series of fresh ones, since there is considerable shrinkage of the feet and ears through drying.

The great majority of my specimens are freshly killed at the time of measurement. Death is induced by ether, in a special jar arranged for the purpose.

[5] Cf. Howell, 1924. Doubtless atmospheric conditions, both temperature and humidity, would affect the results of such a test.

MEASUREMENTS OF THE FRESH BODY AND ITS APPENDAGES

All measurements (except weighing) are repeated, the mean of the two figures being employed in my computations. Furthermore, the second measurement of a given character does not in general immediately follow the first, the two being separated by the measurement of some other character, with consequent readjustment of the body and the instruments. If the difference between the first and second reading exceeds one millimeter, in the case of the body or tail, or two-tenths of a millimeter in the case of characters which are measured to tenths, the measurement is repeated for a third, and, sometimes even more times. It is only in a small proportion of cases, however, that the allowed discrepancy is exceeded.

Before giving the nature of the linear measurements, a few words are desirable regarding the instruments employed. Two kinds of caliper are used (fig. 2). One is a sliding caliper of steel, with a range of twenty centimeters, graduated in millimeters, and provided with a vernier by which tenths may be read. This caliper I use for the measurements of total length and of tail. For the finer measurements (foot, ear, etc.) I prefer a caliper of lighter build, provided with a dial, graduated to tenths. The one which I have used for many years was made to order by the B. C. Ames Co. of Waltham, Massachusetts. The lower figure shows a somewhat similar instrument of German make. Dial calipers should be calibrated occasionally, since the points may be worn or bent, or the hand may shift position.

The measuring frame (fig. 3), which is discussed more fully below, is made of California redwood, painted black. (It is important that a soft wood be used). In form, it is a simple square frame, reinforced in the corners, the surface dimensions of the sides being three by twelve inches. The pinch clamp for holding the tail should be lined with cloth or adhesive tape.

(1) *Total length.* This is the distance from the tip of the snout to the tip of the tail, measured to the nearest millimeter. In taking this measurement, the body is laid, with the dorsal side down, upon the measuring frame, and the base of the tail is inserted into the clamp of the instrument, the head being directed to the right. A slight stretching of the body is effected by means of a 25-gram weight, fastened to a fine brass wire. The latter passes over a pulley and terminates in a loop which is slipped over the upper incisor teeth. The tail is straightened by the fingers without stretching it, and a small shawl-pin inserted into the wood to mark its posterior end (exclusive of terminal hairs).

(2) *Tail length.* In measuring this character, the body is held head

down, and pressed with the left hand against the corresponding side of the frame, the dorsal surface of the animal being in contact with the latter. The basal part of the tail, previously pierced by a small shawl pin, which is used in holding it, is pressed with the right hand against the upper (horizontal) side of the frame, and the body as a whole is drawn back and forth with both hands across the angle of the frame, until the latter fits into the point of junction between the trunk and tail. When this "breaking point" is found, the pin is inserted firmly into the wood. The tail is now straightened out, without being stretched, along the horizontal surface of the frame, and a second shawl-pin inserted to mark its termination (fig. 4). After removal of the mouse, the distance between this second pin and the angle of the frame is measured to the nearest millimeter.

Mammalogists frequently designate the tail measurement obtained by them as being that for "tail vertebrae," implying that the entire caudal series has been included. It would, of course, be far preferable to record the tail length as thus defined, but for mice at least this appears to be impracticable. In reality the "breaking point," which is located either by ruler or upon my frame, is several vertebrae removed from the commencement of the caudal series. The examination of numerous skeletons shows that the first two caudal vertebrae (counting four in the sacrum) commonly lie in advance of the posterior end of the pelvic arch, while radiographs (fig. 5), which I owe to the kindness of Dr. A. B. Smith of La Jolla, make it plain that the latter may not extend to the angle of the frame during measurement. Two to three or more caudal vertebrae are thus excluded from the tail measurements of these animals, with a consequent reduction of at least five millimeters, even in a small mouse.

(3) *Body length.* This is not directly measured, but is computed by subtracting (2) from (1). In my own statistical studies, I deal with body length and tail length, but never with total length. The ratio of tail length to body length, expressed as a percentage, I have likewise found to be a character of great value.

(4) *Foot length.* The left foot is employed for measurement, except in cases of injury to this. The plantar surface is held firmly against the top of the frame, the toes pointing to the left, the heel to the right. A small shawl pin is passed through the metatarsal region into the underlying wood. If necessary, the metatarsus and phalanges must be pressed down or manipulated by hand until they lie straight and flat. The distance from the heel to the tip of the claw of the middle digit

(which is nearly always the longest one) is measured to the nearest tenth of a millimeter. The observer should aim to hold one point of the caliper closely enough to the heel to compress the hairs of this region, so that the skin will be stirred slightly when the instrument is moved to and fro. Slight differences in manipulation may result in discrepancies amounting to a considerable fraction of a millimeter.

(5) *Ear length.* I have invariably employed the measurement of the ear "from notch," since this gives a larger value, and is easier to determine exactly, than the measurement "from crown." The left ear is the one ordinarily measured. The mouse is laid in the palm of the left hand, right side down. The distance from the bottom of the "notch" (which appears to be homologous with the *incisura intertragica* of man) to the most distant point of the tip is measured to the nearest tenth of a millimeter. Frequently the ear is somewhat puckered and must first be straightened with the fingers.

(6) *Weight* is taken by means of a "Cenco" balance, and is recorded in grams and tenths.

(7) *Width of dorsal tail stripe.* This is an important character in some species of *Peromyscus*, as well as in some other genera of rodents. After removal of the skin of the mouse, the skin of the tail is slit open along the mid-ventral line, from base to tip. It is then opened up with the fingers and the inner, moist surface pressed tightly, throughout its entire length, to a strip of (preferably black) cardboard. Care must be exercised to prevent turning the edges under. In cases where the mouse is not to be skinned, the skin of the tail is removed, and treated as described. The length of the tail stripe is next determined approximately and the mid-point marked off on the card. At this mid-point, the total width of the skin is measured in millimeters and tenths, then the width of the stripe. The value used in my computations is the ratio of the width of the stripe to the circumference of the tail as indicated by the width of its skin.

(8) *Length of tail stripe.* In most species of *Peromyscus* which possess a tail stripe at all, this extends throughout the entire exposed part of the tail, and there would thus be no object in measuring its length. In *P. p. albifrons*, however, and in some of my hybrid forms, the tail stripe is incomplete, extending from the base for a varying distance toward the tip. The length of this vestigial stripe is measured to the nearest millimeter. It is sometimes difficult to define its limits with any accuracy, owing to the occurrence of scattered pigmented hairs, which may continue beyond the stripe proper.

FOOT PIGMENTATION

The skin of the soles of the feet of *Peromyscus* is pigmented to a variable extent, at least in some species. Since the amount of this pigment differs in characteristic fashion in various geographic races, and since the individuals of a single race may display genetic differences of the same sort, I have long been accustomed to grade the feet according to a quantitative scale. For this purpose, the left foot is removed from the body, tagged, and placed in 70 or 80 per cent alcohol, being kept thereafter in the dark. After a varying period in alcohol,[6] the feet are placed for a few days in equal parts of 70 per cent alcohol and glycerin, next into pure glycerin.

They are graded according to a standard which is necessarily arbitrary. Five grades are recognized, 0, 1, 2, 3, and 4. In the 0 grade are placed specimens which show no pigment to the (my) naked eye, though examination with a powerful hand lens may reveal a few chromatophores. At the opposite extreme are placed the darkest feet which I have found. Early in my studies, I selected a "standard" set (two of each grade), which are kept in vials and transferred to Syracuse dishes for comparison with the specimens under examination. All comparison is done with the aid of a hand lens.

The task of grading is complicated somewhat by the fact that pigmentation varies in extensity as well as intensity. It is my own endeavor to pass judgment on the *amount* of pigment present, which of course is the product of the two factors.

That the actual results of such grading may be fairly accurate, or at least consistent, is indicated by the fact that parent-offspring correlations for this character are as great as for any of the quantitative characters which I have considered in these studies. (Sumner, 1923).

MEASUREMENTS OF THE SKELETON

I shall discuss these very briefly, since I have not included such measurements in my more recent studies. This has resulted not from choice but owing to unavoidable limitations of my time and funds. Some 2,300 skeletons (or partial skeletons) have, however, been prepared, and the measurements from these have been reported

[6] I have not carefully standardized this phase of the procedure, since the dark skin pigment of *Peromyscus* is very resistent to both alcohol and glycerin. In the latter medium, at least, it appears to be unchangeable, even after the lapse of years.

upon, to a large extent, in several previous papers (Sumner, 1915b, 1918, 1920; Sumner and Huestis, 1921). I am still saving, in alcohol, the bodies of all specimens which are measured, with a view to the possibility of their being later utilized by someone for the study of skeletal characters.

The skeletons were prepared by F. H. Holden, and Miss Lula M. Burt, both at that time assistants at the Museum of Vertebrate Zoology of the University of California. The methods of maceration and cleaning employed by Mr. Holden have been described in a paper by him (Holden, 1914). It is my belief that Miss Burt followed the same or a similar method.

The linear measurements were taken with the dial caliper above referred to, and the gravimetric measurements with a chemical balance. It was first believed to be necessary to dry the bones in a vacuum desiccator, but this procedure was discontinued in the belief that it involved needless trouble.

The characters measured (or counted) were as follows:

(1) *Number of tail vertebrae.* These were counted from the first of the caudal series (the fifth vertebra, commencing with the most anterior one in the sacrum has been so designated) to the last minute nodule of bone discernible at the tip with a low-power objective.[7] The number of caudal vertebrae varies with the species and subspecies, longer-tailed forms having a larger, though not a proportionately larger, number. There are also interesting individual differences in this respect (Sumner, 1918).

(2) *Length of skull,* from anterior end of nasals to upper rim of occipital foramen.

(3) *Length of femur,* "maximum length from top of head to bottom of internal condyle."

(4) *Length of innominate bone,* from anterior end of ilium to most distant point of pubis.

The separate weight of the two *femurs* and *innominate bones* and the two halves of the *mandible* were determined in milligrams and tenths, for an extensive series of skeletons, in the course of studies by Sumner and Huestis (1921), designed to test the inheritance of asymmetry.

Measurements of Coat Color

These are of two sorts: (1) colorimetric analysis of a selected area of the colored region of the pelage, and (2) areal measurements, indicat-

[7] In some cases, it is evident that two of these nodules represent the two epiphyses of a single vertebra.

ing the proportional part of the skin occupied by colored hair or by special regions of the latter.

COLORIMETRIC ANALYSIS

General

One need hardly urge the importance of being able to characterize with some exactness the colors of biological objects. But it is not likely that many biologists would assert that present practices meet this need at all satisfactorily. I feel that I can no longer evade the task of describing the procedure which I have adopted in my own attempts at color analysis, however unprepared I may be to deal at all adequately with this highly technical subject. Fortunately, I have been able to secure the advice of several competent specialists in optics, one of whom, Doctor Anderson, has kindly consented to criticize this section of my manuscript.[8]

My own efforts in this field have been necessitated by the inadequacy of the methods commonly employed by zoologists for designating the colors of animals, and particularly by the impossibility of thus making quantitative determinations suitable for employment in statistical studies.

Most recent American zoologists who attempt to designate the colors of animals have recourse to Ridgway's Color Standards and Color Nomenclature (1912). This set of plates undoubtedly marks a great advance in the endeavor to produce a standard set of colors and shades, and it will probably long continue to have a wide range of usefulness, in cases where great accuracy is not required. But this, or in fact any possible set of "standard" colors has very serious limitations, so serious indeed that its use is quite inapplicable to studies demanding a quantitative treatment of data. Let me state some of these limitations.

(1) Such an object as a mammalian pelage, even in an area of relatively uniform color, is far from being homogeneous in appearance. Different types of hair differ from one another in their contained pigments, and the entire surface is streaked with minute shadows and gleams of light. To make an accurate visual comparison of such a composite object with a homogeneous surface of colored paper is

[8] My thanks are particularly due Dr. J. A. Anderson, of the Mount Wilson Observatory, Prof. F. S. Brackett, of the University of California, and G. S. Radford, of New York City. The use of the Ives Tint Photometer was originally suggested to me by Prof. E. P. Lewis, of the University of California.

strictly impossible. One can endeavor mentally to blend the various components, and compare the resulting color with one or another of the "standard" set, or he can single out some one dominant component, and endeavor, for the time being, to overlook the others. But the result at best is a rather crude approximation.

(2) Allied to the first difficulty is the close relation between the appearance of a mammalian pelage and the incidence of the light. Quite different results will be obtained, depending upon whether the head or the tail end of the specimen is pointed toward the light.

(3) To compare two colored surfaces satisfactorily, it is necessary that these should lie in juxtaposition, without the presence of another colored surface between them. This is impossible with any set of "standards" bound in book form.

(4) Even with the extensive set of colors contained in Ridgway's book of standards, it is frequently impossble to "match" a particular sample. This is because the eye can detect a vastly greater number of hues, tints and shades than are portrayed in the book.

(5) Of vital importance for statistical studies is the need of making determinations which are quantitative in the sense of being expressible in figures. This is obviously impossible to accomplish through any system of matching "standards." Two series of skins, each displaying a considerable range of variability, may differ slightly in their average color values. Such a slight mean difference, even if statistically significant, would probably not be revealed by the customary procedure. Once more, it would be impossible to compute parent-offspring or fraternal correlations, demonstrating the heritability of small color differences, unless the color values of every individual could be expressed quantitatively.

(6) Another difficulty, and a fundamental one, is the futility of attempting to identify two apparently identical colors by ordinary visual means. Granting that the observer is possessed of normal color vision (although one man in about twenty-five is color-blind), there remains the fact that precisely the same visual appearance may be produced in quite different ways. To illustrate, combinations of monochromatic red and green may be matched by a pure yellow, having a wave length intermediate between the other two.

(7) Finally, colorimetric tests that I have made of many of the plates of Ridgway's "Color Standards" show that they do not always conform to the rules supposed to have been followed in their preparation (see footnote 26, p. 202.).

Preparation of skins

Before discussing the colorimetric methods which I have employed in the study of rodent pelages, some space must be devoted to the subject of preparing the skins.[9] Comparable results necessitate the preparation of flat, clean skins, stretched with a reasonable amount of uniformity.

The skin is removed from the body in a manner closely similar to that commonly employed by the collectors of museum specimens.[10] My only departures from customary procedure at this stage consist in severing the leg bones considerably nearer to the feet, and in carrying the ventral incision of the skin forward to the neck region. After removal of the skin from the body, this latter incision is carried through to the mouth, bisecting the lower lip. Thereafter, the fat and other tissues adhering to the skin are removed with forceps, and the entire inner surface, including that of the legs, is thoroughly dusted with arsenic by means of a cotton swab.

The skin is now placed, fur side down, in a stretching frame (fig. 6), consisting of a disk of wood, twelve inches in diameter, mounted on a pedestal about sixteen inches high, and carrying on its periphery eight small pulleys, spaced at equal intervals. It is here subjected to the slight tension produced by eight 25-gram weights. The latter are fastened to heavy linen threads, which pass over the pulleys and terminate in small pinch-clamps, for attachment to the periphery of the skin. The eight points of attachment are the fore and hind feet, the tip of the snout, the base of the tail, and the lateral margins of the skin about midway between the bases of the fore and hind limbs.

The use of the frame here described is admittedly somewhat inconvenient in the field, and I have on such occasions dispensed with it, merely pinning the skins directly to redwood boards, as described in the next paragraph. Furthermore, the preparation of skins by any method is difficult in arid regions, owing to rapid drying and loss of elasticity. For these and other reasons, I commonly ship my entire catch alive to the laboratory, so far as possible, and prepare the skins in the humid atmosphere of the coast. If drying is unavoidable, skins

[9] Substantially the same procedure as that here described has been followed by me for many years, though it differs in some important respects from that outlined in my paper of 1909. No account of the improved method was published, however, until the paper of Collins (1923). Thereafter, I have further modified this procedure by carrying the ventral incision forward to the mouth, a change which was adopted at the suggestion of G. S. Miller, Jr.

[10] See, for example, the excellent illustrated account by H. E. Anthony (1925).

may be moistened by laying them in contact with damp absorbent cotton.

The skin is left in the frame for about fifteen minutes (commonly while the next mouse is being skinned), and is then pinned to a small redwood board, which is inserted underneath without disturbing the cords and weights.[11] Common pins are driven into the board with a tack hammer, through the same eight points to which the pinch-clamps have been attached. Certain other points are likewise pinned to the board, namely, the lateral flaps of the head, terminating in the severed halves of the lower lip (fig. 7), and three points in the skin of the tail, which has previously been slit open on the ventral side.

Skins are left on the boards for a minimum period of ten days (less would be required in a dry atmosphere), when they are removed and placed in a bath of benzine or high-test gasoline. At the end of twenty-four hours, they are carefully drained, one by one, and transferred to a second bath. This procedure is necessary in order to remove all traces of grease. After another day in benzine, they are taken out by forceps, drained, and laid to dry, fur side up, upon several layers of clean, flat, newspaper. It is well to shift them a few times, until the greater part of the benzine has evaporated. They should then be left for a further two days to insure complete drying. If the hairs still cohere, a third bath of benzine should be employed.

That benzine or gasoline does not appreciably affect the pigment of the hair, at least in the course of a few days, is evident from colorimetric tests made before and after this treatment.[12]

Ten skins of my *polionotus-albifrons-leucocephalus* series, including dark, medium and pale skins, were selected for one of these tests. In this case, skins were chosen, the hair of which showed slight or no traces of grease at the outset. The mean values (for meaning of these figures see below), before and after two days treatment with high-test gasoline, were as follows:

	RED	GREEN	BLUE-VIOLET	R:G	$\frac{R - BV}{R}$
Before	18.77	14.85	12.85	3.05	32.9
After	18.40	14.60	12.57	2.95	33.1

[11] In my own procedure this board is commonly 10 by 4½ inches in surface area, and ¾ inch thick. When inserted, it should be flush with the skin. This is made possible by keeping another board of the same dimensions permanently on top of the disk.

[12] Previous experiments by Dr. H. H. Collins and myself had given us satisfactory assurance that the hair pigment was not appreciably altered by benzine.

Ten skins were next selected which were obviously greasy, the hair being sleek and matted. The color values were as follows:

	RED	GREEN	BLUE-VIOLET	R:G	$\frac{R - BV}{R}$
Before	19.52	16.22	14.32	2.72	27.5
After	20.70	17.12	15.05	2.70	28.7

In the case of the first of these series, there is a decrease of about two per cent in the mean figures for the three color-screen readings. This decrease is probably of no significance, particularly in view of the results from the second series of skins. For the latter we have an increase of five or six per cent in these mean values, indicating a gain in brightness which is probably due to the removal of grease. The effect of oil or moisture in darkening the appearance of human hair is familiar. That no appreciable change in either hue or saturation has occurred in either lot of skins is made probable by the approximate agreement of the values for R:G and $\frac{R - BV}{R}$, before and after treatment. These last figures are as close as could be expected, in view of the mode of computation employed (see page 200).

It is by no means true, however, that all fat solvents leave the pigments of the hair unaltered. Huestis (1925) has called attention to the changes produced by xylol in the colors of hair samples, as viewed with the microscope. In view of this circumstance, it seemed possible that gasoline might have a similar effect if the treatment were sufficiently prolonged. I have thought it worth while to test this point. Four skins (two pale and two dark) were divided longitudinally, one-half of each being left for four weeks in high-test gasoline, the other being kept as control. At the end of this period careful scrutiny by myself and several of my colleagues failed to reveal any difference of appearance between the treated and the untreated halves, when these were reunited along the severed margins.[13]

Skins used for colorimetric studies must occasionally be exposed to daylight, and during the actual tests to rather intense light from an electric lamp. It is well known to museum curators that prolonged exposure to sunlight (even if indirect) has a bleaching effect upon the pelages of mammals and the plumages of birds. It is a matter of

[13] Trustworthy readings of these half-skins with the tint photometer proved to be impossible, owing to practical difficulties which need not be detailed here.

interest, therefore, to determine whether appreciable effects are likely to result from the treatment which the skins receive in the course of these colorimetric studies.

Some years ago, Doctor Collins prepared a series of ten skins, which were divided longitudinally into equal parts as described in a previous paragraph. One-half of each skin was exposed to daylight in a north room for a period of about five months, the other was kept as a control in the dark. With one or two possible exceptions, no change is evident to the eye when the two halves are examined in juxtaposition. I have recently made a similar test, with ten other skins. In the present case, they were kept for four weeks in indirect sunlight. As stated above, tint photometer tests proved to be impracticable with these divided skins, but the two halves of each were carefully compared. I was not, in a single instance, able to detect the slightest difference of appearance between the exposed and the unexposed sides.

It seems plain, then, that no appreciable change may be expected to result from occasional exposure to subdued daylight, even in the course of years. On the other hand, it is conceivable that perceptible alterations might be produced by the much more intense light employed during the actual photometer measurements, even though these were of brief duration.

To test this point, the half skins last referred to were later exposed to direct sunlight, behind window glass, for periods aggregating ten hours. Even in this case, however, no difference in appearance could be detected between the two halves, either by myself or by three of my colleagues in the laboratory.

Briefly stated, the advantages of the method of preparing mammalian skins here described are as follows:

(1) A perfectly flat surface is made possible for photometric examination. Unequal illumination, due to curvature, is thus eliminated.

(2) The skins are stretched to an approximately equal degree, whereas ordinary "study skins" differ widely in the degree of filling. Differences of stretching or shrinkage appreciably affect the shade.

(3) Flat skins may readily be cleaned of grease with benzine, whereas this is far more difficult in the case of study skins, which are filled with cotton.

(4) One is able to observe practically the entire pelage at one glance, a circumstance which facilitates comparisons among series of skins.

(5) Flat skins occupy far less storage room.

It can hardly be seriously contended that the customary study skins

of our museums reproduce the original form of the body to an extent which greatly increases their value.

Area of pelage selected for analysis

A blended or average impression of the entire pelage would be of little value, even if it were practicable to obtain this. With the instrument which I employ in color analysis, a rectangular area approximately 28 by 15 mm. in extent is comprised within the field. In my earlier studies (all of those prior to the *polionotus* series) the skin was so placed in the instrument that this rectangle was transversely situated, comprising a strip which covered nearly the entire width of the colored area of the pelage, and terminating posteriorly about 15 mm. in advance of the base of the tail.

Owing to the smaller size of the mice of the *P. polionotus* group, it has been found necessary that the major axis of the rectangle should be longitudinal in relation to the skin of the animal, the area terminating about 22 mm. from the base of the tail (fig. 7). In either case, the mid-dorsal line of the specimen passed through the center of the field. The field thus included the mid-dorsal stripe of darker hair, found in most mammalian skins, and a part of the lateral, somewhat paler area, situated on each side of this. Care has been taken to exclude altogether the ventral white region of the pelage, since the inclusion of even small areas of this considerably affects the values obtained.

In my practice, the skin is placed upon a rectangular block of wood, 86 by 62 mm. in surface dimensions and 39 mm. high. When the skin has been properly placed on this block, it is covered by a plate of thin aluminum, having the same surface dimensions as the block, and containing a rectangular aperture, corresponding in size to the visible field previously discussed (28 by 15 mm.). This aperture (in my more recent studies) is covered by a thin ("no. 1") cover-glass, fastened by rubber cement to the lower surface of the aluminum plate. The upper surface of the latter is coated with a dull black paint. Two clamps, resembling those on a microscope stage, but larger, serve to hold the aluminum frame and underlying skin firmly in position.[14] (see fig. 8).

When the pelage is thus fixed in the object-holder, and the latter properly placed in the instrument, the direction of the hair is approxi-

[14] I have described and figured this object holder, since it was not furnished by the dealers, and was the outcome of considerable experimenting on my part. The exact size and position of the window must be determined experimentally, and they doubtless differ somewhat with each instrument.

mately perpendicular to a line drawn to the center of the lamp. In other words, the pelage is illuminated from the side, rather than from the front, a procedure which seems calculated to reduce surface reflections to a minimum.

The Ives Tint Photometer[15]

Despite considerable drawbacks, this instrument is better adapted than any other that I know of for use in quantitative colorimetric studies of mammalian pelages. This and the further fact that much of the ensuing discussion would apply to any apparatus of similar type seems to justify a rather lengthy treatment of the subject.

The instrument has already been discussed by me briefly in several previous papers (Sumner, 1921, 1923, 1924, 1926; Sumner and Collins, 1922), but an adequate description has not, so far as I know, been published. The descriptive circular provided by the manufacturers is thoroughly unsatisfactory, as regards both fact and theory. The whole procedure described in the present paper had to be worked out experimentally, a task which I have only recently completed, although I first undertook the use of this instrument more than five years ago. In the course of this period, I have several times found reasons for revising my technique, so that the color values given in my different papers are not always comparable with one another. For any given paper, however, the values are strictly comparable, and thus the conclusions stated are not in the least invalidated by these changes of procedure.

In principle, the instrument is rather simple. It will perhaps be most intelligible if I commence with the object under observation, and work back from this to the observer. The skin, suitably fastened in the object-holder (see above), is placed upon the lower, forward platform of the instrument (figs. 10, 11). To the left of the object-holder, on the same platform, is a smooth, level block of magnesium carbonate, furnishing the standard white. The two are uniformly lighted by a

[15] Referred to in my earlier papers as the "Hess-Ives Tint Photometer," the name formerly used by the manufacturers. Various forms of this instrument have been made. A model has been recently produced by the Palo Company, which differs in important respects from that here described, but which I think would not serve as well for the study of mammalian pelages. The "Ives Colorimeter" referred to by Luckiesh (1915) is an earlier instrument, which appears to have differed fundamentally from those later produced. It is possible that other forms of colorimeters would be more satisfactory than the one here described.

powerful tungsten lamp, covered in front by a window of "daylight" glass. A vertical mirror (fig. 11, *Vm*) behind them adds by reflection to the light which falls upon these directly. Since the area of pelage under observation is covered by a strip of no. 1 cover-glass, the same must be done with the corresponding area of the magnesia block. For this purpose, a similar aluminum frame is employed.[16]

Light reflected in a vertical direction from the two objects is received by a mirror (fig. 10, *Im*) set at an appropriate angle, and reflected into the box (B), which constitutes the main body of the apparatus, through two apertures (fig. 11), controlled by adjustable shutters. The right-hand[17] shutter is commonly held in a fixed position by means of a set-screw, but the left-hand one is controlled by a lever (fig. 10, *Le*), moving over a scale, graduated from 0 to 100.

The two parallel shafts of light impinge upon a prism combined with a cylindrical lens (fig. 9, *P*), as one result of which the two fields to be compared are brought into juxtaposition with one another. This double shaft of light now passes through a wheel-shaped structure (fig. 9, *Bw*), bearing twelve plano-convex lenses, which is rotated rapidly by a small electric motor (fig. 10, *Mo*). The object of this is to render homogeneous each half of the visual field.

The double shaft of light now passes through one or another of the color screens (fig. 10, *cs*), which may be interchanged at will or removed altogether. Thereafter, it reaches the eye of the observer through an eye-piece (*E*), provided at the end with a pin-hole diaphragm.

What the observer sees is a single, circular visual field, divided vertically by a scarcely perceptible line, each half being homogeneously lighted. Owing to the interposition of the prism, these halves have been transposed, so that the light from the magnesia block now appears on the right hand side.

[16] The use of these cover-glasses constitutes a modification of my original procedure, and has been employed only in the studies reported in my 1926 paper. The advantage of pressing down the hair surface seems obvious. For some unknown reason, the presence of the two cover-glasses affects the two sides of the field unequally, resulting in a slightly lower reading for the object than when the latter and the magnesia block are both left uncovered. After several days devoted to seeking the cause of this phenomenon, I am still without the slightest clue. The difference, which is shown by colored papers as well as by skins, is greatest for darker shades, and disappears altogether when a second magnesia block is used in place of the object. For shades within the range of those common among mice, a reduction of between 5 and 6 per cent is manifested, and this correction should be added, accordingly, to all readings of these skins.

[17] From the point of view of the observer, at the other end of the instrument.

When a reading is to be taken, the object is first placed in position and the motor started. One of the color screens is now inserted, and the lever is shifted until the two sides of the field appear to be equally illuminated. Owing to the presence of the screen, they likewise appear of the same color. With practice, one can easily obtain readings to within a half degree on the scale. After recording the reading for the first screen, say red, one substitutes the next (green) one, and repeats the adjustment of the lever. The value for green is recorded, and the blue-violet screen then substituted. (These screens, for convenience, are mounted on a single slide.)

In my own practice, I repeat observations with each specimen at least once before removing the latter from the object-holder. Each reading is recorded to the nearest half degree.[18] Likewise, with every skin, the whole process is repeated on a subsequent day, the mean of the two day's readings (with each screen) being the one employed in my calculations.[19]

Owing to the mode of graduation on the scale, the readings are in percentages. A reading of 25 for red, for example, means that the red rays reflected from the magnesia block had to be cut down to 25 per cent of their original value before they balanced those reflected from the skin.

It is needless to say that a complete analysis of the color of any object with this instrument would require the use of a series of color screens extending through the entire range of the spectrum. This is, of course, impossible in practice, but instructive results can fortunately be obtained with a quite limited number of screens. In the Ives tint photometer, three of these (red, green and blue-violet) are commonly employed.[20] It should be borne in mind, however, that these screens

[18] A range of accuracy no greater than this implies, of course, a considerable percentage of error where we are dealing with low absolute values. In order to render the readings more delicate, in the case of darker objects, a gray block of known shade may be substituted for the white one. Such blocks are prepared from powdered magnesia and lampblack, mixed thoroughly while damp. (Knowledge of this method I owe to G. S. Radford, a specialist in color measurement. I have not yet tried it.)

[19] The mean difference (regardless of sign) between the first and second day's readings, based upon thirty pelages (ten of each subspecies), taken at random from the series employed in my recent *P. polionotus* paper (1926), is as follows: red, 0.40; green, 0.27; blue-violet, 0.38. (These figures are fractions of a degree on the scale.)

[20] The blue-violet was termed "violet" in my last paper discussing this subject (1926). It seems preferable, however, to employ the term used by the manufacturers, and which I have myself used in earlier papers.

give accurate information only so far as concerns the wave lengths which they actually transmit. Thus orange, yellow and blue-green are not actually measured by the present series of screens. Nor are all the various colors of objects to be regarded as due to combinations of the three so-called "primary" colors, in the sense that white light is resolvable into the colors of the spectrum.

There is much popular confusion on this subject due to a failure to distinguish questions of color sensation from questions relating to the physical causes underlying these. Because the sensation "yellow" may be produced by super-imposing beams of red and green light upon the same white surface, it does not follow that physically yellow light could be decomposed into red and green by passing it through a prism, nor that such light would be transmitted by either red or green color-screens if these were strictly monochromatic.

The fact that an object appearing yellow to the eye may none the less give fairly high values with all three of our color screens is due to two chief causes: (1) Colors in nature are rarely if ever pure. In addition to the predominant hue of an object, the latter reflects light of many other wave lengths, commonly indeed the entire spectrum. In the latter case, we may have considerable "white" in our object, i.e., its color is not saturated. (2) The color-screens themselves are not strictly monochromatic, but transmit a limited amount of light throughout a considerable range of the spectrum. Such "leakage" is not accountable, however, for any large proportion of the light ordinarily transmitted by these screens.

For reasons just stated, there are, of course, theoretical objections to this or any other method of color analysis which is based upon the use of only three screens. The belief that readings with such a set of

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The values of these three colors in wave-lengths, as determined spectroscopically by Dr. J. A. Anderson for the set chiefly used by me, are as follows:

		mμ
Red, lower limit		603
Green	Upper limit	600
	Mid-point	530
	Lower limit	480
	Points of half transmission (approximate)	570, 505
Blue-violet, upper limit		510

The screens supplied by the manufacturers differ somewhat in density and therefore in the upper and lower limits to the wave-lengths transmitted. For transmission of Ives color-screens see Troland, 1922, p. 568.

color screens fairly characterize the light reflected from a given object rests upon the assumption that the intervening portions of the spectrum are distributed similarly in all cases. Were the lines connecting R and

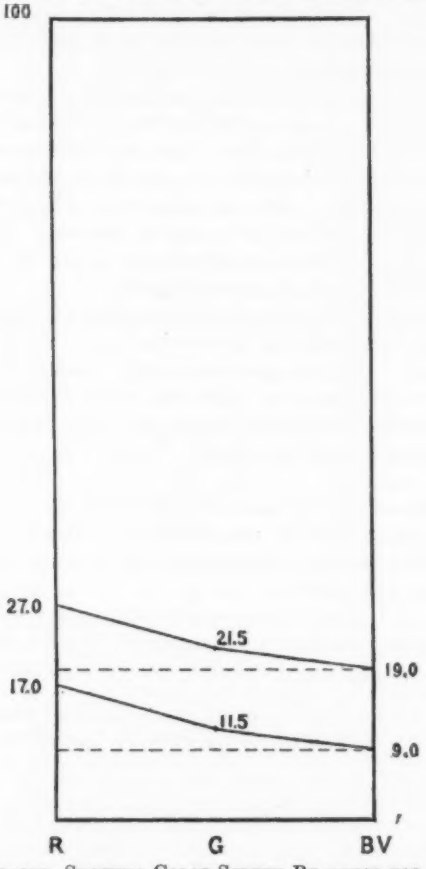

FIG. 1. GRAPHS, SHOWING COLOR-SCREEN READINGS FOR SKINS OF P. P. LEUCOCEPHALUS AND P. P. ALBIFRONS, RESPECTIVELY

G, and G and BV, respectively (fig. 1), in all cases straight lines, these three "samples" of the spectrum might be accepted in general as representative. But it is evident that this can not always be true.

However, the thing we most need in studies of variation is a measuring stick which is uniform for all specimens measured. In the present case, it seems certain that within the limits of the material at hand our results are sufficiently comparable for an accurate analysis of individual and racial differences. I have earlier called attention to the fact that the wide differences of color which are to be observed among the pelages of mice are due chiefly to differences of brightness and of saturation, and very little to differences of hue. The dominant hue is closely similar in nearly all cases, and this would probably hold true for a wide range of mammals. Moreover, if greater accuracy is required, it is always possible to use additional color-screens.

A great and obvious advantage of the present method of colorimetry is the fact that the values recorded are in no way dependent upon the observer's proficiency in "matching" colors. What are compared are differences of luminosity, in areas having the same hue and saturation. It is probable, indeed, that a color-blind observer would be as successful in this field as a normal person.

The method employed in interpreting readings with the Ives tint photometer may be best illustrated by a few sample cases. One skin of *Peromyscus polionotus leucocephalus* Howell gives the following readings: red, 27.0; green, 21.5; blue-violet, 19.0. One of *P. p. albifrons* Osgood gives the following: red, 17.0: green, 11.5; blue-violet, 9.0. These figures represent percentages of the readings which would have been obtained had a second block of magnesium carbonate been substituted for the skin. Had this been done, the values, with all these screens, would have been 100.

In figure 1, these readings have been plotted as ordinates, those for the same specimen being connected by a line. Considering the upper one of these lines (that for the *leucocephalus* skin) by itself, the area included between this and the upper limit of the rectangle might be considered as the percentage of "black", that is to say, the total reduction in luminosity of the specimen, as compared with the standard white. For reasons which will be stated below, I now doubt the expediency of computing values for "black," and no longer do this. The value of the highest reading (in all cases red) serves as a good index of the brightness of the pelage, and inversely of the proportion of black.[21]

[21] In my previous papers, with the exception of the first (1921), I gave as the value of "black" 100 minus red. In the 1921 paper, I employed still another method of computation, based upon the circular of instructions supplied with the instrument.

The area below the dotted line (at the level 19.0) represents the percentage of "white." In other words, all of the blue-violet (19 per cent), together with equal amounts of green and red, is regarded as due to the non-selective reflection of light from the specimen.

The triangular area lying between these two lines represents the percentage of "color", in the narrow sense. The spectral position of this hue is not, of course, revealed by the readings of the instrument. It is indicated crudely by the ratio of the "free" red to the "free" green, that is, the amounts of those colors which are left after deducting the 19 per cent regarded as contributing to the production of white. In the present case, this ratio ("R:G ratio")[22] is 8:2.5 = 3.2.

Another derived value of importance is expressed by the fraction $\frac{R - BV}{R}$. This is the ratio of the "free" red to the entire amount of red transmitted by the screen, thus giving us an index of saturation for this color. In the present instance, this fraction (expressed as a percentage) has the value 30.[23]

For the *albifrons* skin, the corresponding color-screen readings are 17.0, 11.5 and 9.0. The R:G ratio is 3.2, thus agreeing exactly with the *leucocephalus* sample. Such close correspondence may be regarded as accidental, however, since specimens belonging to each of the two series display considerable differences in this respect. Indeed, it may be said that *individual* differences in the R:G ratio are commonly non-significant, owing to the range of error of the primary readings. Had the reading for violet, for example, been entered as 8.5, instead of 9.0 (readings are recorded to the nearest half degree), the R:G ratio would have been 2.8, instead of 3.2. On the other hand, it must be insisted that the mean ratio for a considerable *series* of individuals represents a close approximation to the truth.

[22] Of course, we should have a *red* : *green* ratio $\left(\text{more correctly } \frac{R-BV}{G-BV}\right)$, only in cases like the present, where the reading for red is highest and that for the blue-violet lowest. If quite different colors were under consideration, we might have a *red* : *blue-violet* ratio, or a *green* : *blue-violet* ratio. The general term "color-ratio" is perhaps applicable here.

[23] One may likewise express the degree of saturation by the fraction $\frac{R-V}{V}$, i.e., the ratio of "free" red to "white," as was done in my last paper in this JOURNAL (1926). In the present case, this would give the value 42. The procedure here adopted seems somewhat preferable, however.

The index of saturation $\frac{(R - BV)}{R}$ is 47 for *albifrons*, as compared with 30 for *leucocephalus*. This means, of course, that the color of the latter is far less saturated, that is, contains a much greater admixture of white. This difference is highly characteristic of the two races (Sumner, 1926).

It must not be supposed (although I was myself at one time guilty of this error) that the chromatic properties of any object may be reproduced upon a color-wheel by means of three sectors, having areas proportionate to the percentage of "black," "white" and "color" (of proper hue), referred to above.[24] This is not possible for the reason that the blending of color-sectors on a wheel does not give us the sum of their luminosities, but an average of these. In order properly to reproduce the color values of an object determinations of which had been made by the method described in this paper, it would be necessary to project upon the same white surface three beams of colored light, of relative intensities corresponding to the three values obtained with our color-screen readings. Here the effect would be additive. But even this procedure would give a considerably reduced luminosity, since the three color-screens employed are nearly opaque to the intervening regions of the spectrum.

It is possible, of course, to "match" empirically the colors of many objects by appropriate combinations of sectors upon a color-wheel. For reasons already indicated, this is the more readily done in proportion as the colors to be matched are of low brilliancy and saturation. Useful comparisons of this sort have been made with the pelages of mice (Collins, 1923), but the method is extremely time-consuming, and the results are subject to the same fundamental objections as are those obtained by any process of direct visual comparison.

Since the values obtained with the tint-photometer are not likely to be translated into visual terms by the inexperienced reader, reference to such "standard" colored papers as those of Ridgway may still be helpful at times in giving concreteness to our discussions. It might be worth while, indeed, to prepare a table stating the values of certain of Ridgway's "standards" in terms of our three-color readings.[25] I

[24] Allowing, of course, for the lack of saturation and relatively low brilliancy of all commercial papers.

[25] I have done this personally for a number of Ridgway's plates, which had to be cut into pieces for the purpose. The readings obtained are sensibly influenced by the fact that the colored rectangles are somewhat smaller than the "field" as observed through the instrument. The gray background here exerts an appreciable effect in some cases.

have, however, seldom found it possible to match at all closely the values for a given mouse pelage with those for any one of Ridgway's standards, in respect to all three factors, hue, brightness and saturation. Furthermore, as I have already stated, these "standards" sometimes fall far short of conforming to the rules which their author believed that he had followed in their preparation.[26]

Although the data presented in my published discussions of *Peromyscus* have been obtained exclusively with the three color-screens hitherto discussed (red, green and blue-violet), I have employed two other screens, covering intervening segments of the spectrum. These are yellow and peacock-blue.[27] It is of interest to give the complete readings for the *leucocephalus* and *albifrons* skins above referred to, when all five screens are employed. They are as follows:

	RED	YELLOW	GREEN	PEACOCK-BLUE	BLUE-VIOLET
Leucocephalus	27.0	23.0	21.5	20.0	19.0
Albifrons	17.0	13.5	11.5	10.0	9.0

[26] All of the colored rectangles in any one vertical series are supposed to be of the same hue (that is, of the same spectral position), being variously modified in respect to brightness and saturation. Likewise, in plates I–XII, all rectangles lying in the same horizontal series, above the middle row, are supposed to be of the same grade of saturation, differing only in their hue.

Now the colors on some of the Ridgway plates which I have tested conform fairly well—at times surprisingly well—with the first of these requirements, and this holds for certain plates which are of service in relation to rodent pelages (XV, XXIX, XL). Others, on the contrary, show wide differences in the "color ratio" (see footnote 22), within a single column. On plate II, column 1, for example, this ratio ranges from 6.9 to 26.2, indicating very considerable differences of hue, as well as of shade and tint.

Likewise the dilution with white (decrease in saturation), while it may be fairly uniform for each horizontal row *within the same plate*, may vary widely when corresponding rows of *different* plates (for example, I, II, III) are compared.

[27] Spectroscopic determination of these are as follows:

		mμ
Yellow	Upper limit	615
	Mid-point	570
	Lower limit	550
Peacock-blue	Upper limit	515
	Mid-point	485
	Lower limit	465

It is somewhat surprising, perhaps, that with objects having—so far as they are colored at all—a decidedly yellowish appearance, the reading for red should be distinctly higher than that for yellow. This is likewise true for skins of a much brighter yellow than the present ones, and even for papers which are seemingly pure yellow, e.g., Milton Bradley's "yellow" and Ridgway's "lemon yellow." Such cases merely illustrate the inadequacy of the human eye as an instrument for color analysis.

Before leaving our account of the Ives tint photometer, a few words of caution are desirable for the benefit of those who may be disposed to acquire and use this instrument. The apparatus is distinctly not one to be employed by persons unaccustomed to handling instruments of precision. In any case, some weeks of practice and frequent reëxamination of the same objects are necessary in order to attain proficiency. The beginner is certain to encounter considerable discrepancies and inconsistencies in his results, the causes for which may be quite baffling. Only by studying the minutest details in the operation of the instrument and maintaining the strictest constancy in his procedure will he eliminate these contradictions.

I can only briefly indicate some of the chief sources of error. First of all, should be mentioned the displacement of the lamp and other movable parts of the apparatus. The lamp should be rigidly fixed in position, and the positions of certain other parts closely attended to. Other fruitful sources of discrepancy are failure to properly place the object holder, or to properly locate the area of pelage under examination, or an initial error in making the window through which this is observed. The extent and position of the two areas (both of object and standard white), light from which is included within the two halves of the visual field, must be determined at the outset with great care. Likewise, the equal illumination of the two sides must be checked up at rather frequent intervals, by the use of two magnesia blocks, and changes made when necessary in the aperture controlled by the object-shutter.

Those who have the patience to overcome these difficulties will, I think, be fully repaid for their efforts. It is my firm belief that the foregoing or some similar method of color analysis will have to be adopted sooner or later by those who seriously attempt studies of color variation in mammals or birds.

AREAL MEASUREMENTS

In most species of *Peromyscus*, and in fact many other mammals, we may distinguish two rather sharply demarcated regions of the pelage. The hair of the dorsal surface, extending downward for a varying distance on the sides, is pigmented from base to tips, giving the animal its characteristic gray, brown or buff color. The remainder of the pelage, including the entire ventral region, is white or at least whitish in appearance. This is due to the fact that in the latter region the distal half, more or less, of each hair is devoid of pigment, although it is commonly present at the base. The relative extent of the dorsal colored-region of the pelage, or conversely of the ventral white, is a racial character of considerable importance, showing variations which are in some cases correlated with climatic conditions. The advantage of making quantitative determinations of these areas is obvious.

As stated in another paper (1926), I have found it possible to make these measurements with sufficient accuracy for statistical purposes. Skins prepared as above described (page 189) are employed for the purpose. For making this measurement the skin is laid, hair side up, upon a flat surface and covered with a sheet of transparent celluloid, which is held firmly in place. It should be well lighted from above. For areal determinations, I employ the Keuffel and Esser polar planimeter, no. 4238. The periphery of the entire skin, excluding feet and tail, is first traced with the instrument, then the colored area. The ratio of the second of these areas to the first is the value sought.

From the nature of the case, these measurements can have no high degree of accuracy in an absolute sense. There are certain unavoidable defects in the method, such as, for example, my failure to split open the skin of the limbs. But if the observer adopts, in detail, a constant procedure—and this is all-important—the results are strictly comparable and may be of high value.

In certain members of the *Peromyscus polionotus* group, and in a few other mice, the classification of pelage areas is more complex than that indicated above. In these cases, there are three areas or zones of the pelage to be distinguished: (a) a zone in which the hair is pigmented from base to tip, (b) one in which it is pigmented at the base, but not in its more distal portions; (c) one in which the entire hair, from base to tip, is devoid of pigment, that is, is pure white (Sumner, 1926).

The area (a) is equivalent to the colored area of the pelage, as considered above, and is measured in the same way.

Throughout the combined areas (a) and (b), the hair is pigmented at the base, thus contrasting with area (c), in which pigment is entirely lacking. This difference is conspicuous when the skin is viewed as a transparent object. For making these observations, I employ the simple apparatus used by photographers for touching up negatives. This consists of a box, containing an electric light bulb and having a window of ground glass. In my studies, the box is mounted upon the edge of a drawing board, the window being horizontally placed and flush with the surface of the board. The skin is laid, hair side down, upon the ground glass plane, and covered as before with the celluloid sheet. (See fig. 12.) The "*area of hair pigmented at base*" may be readily determined and expressed as a percentage of the total area of the skin.[28]

Areas (b) and (c) may, of course, be computed separately, if desired, from the foregoing data. In my own computations I have thus far restricted myself to areas (a) and (a + b), or rather to the ratios which these bear to the entire skin surface.

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[28] Here again it is essential that a constant procedure be employed. It is my practice to deduct from the area in question any areas which are devoid of pigment (or of hairs), such as the orbits, the bases of the ears, and certain uncolored patches of hair.

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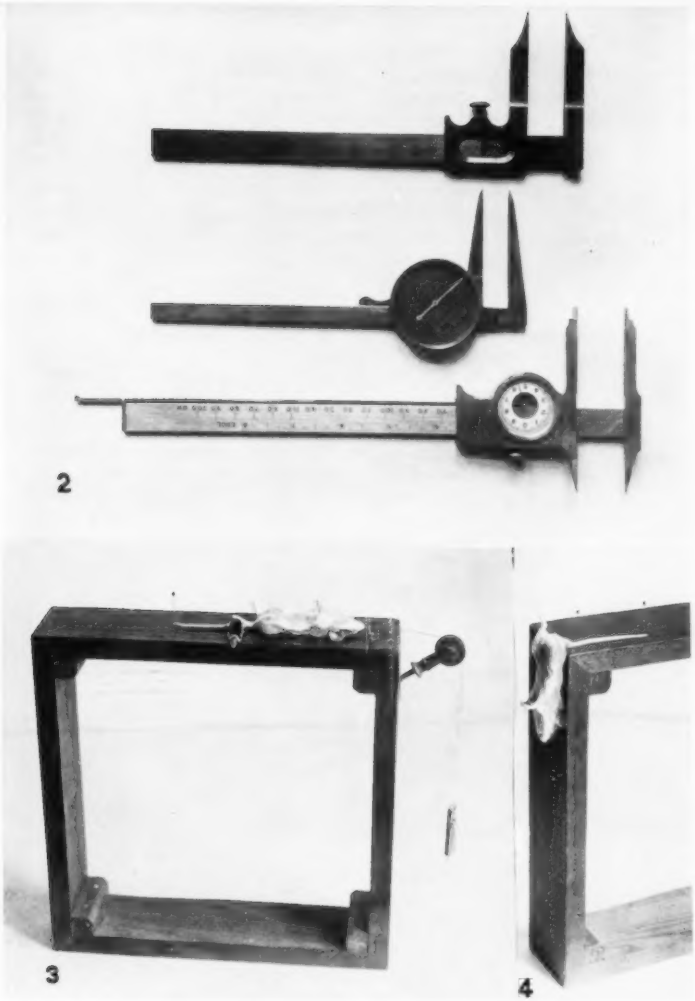

FIG. 2. THREE FORMS OF CALIPER, USEFUL IN MEASURING BIOLOGICAL OBJECTS

FIG. 3. MEASURING FRAME, SHOWING METHOD OF MEASURING TOTAL LENGTH

FIG. 4. MEASURING FRAME, SHOWING METHOD OF MEASURING TAIL LENGTH

Photographs by H. R. Fitch

UNIV. OF MASS.

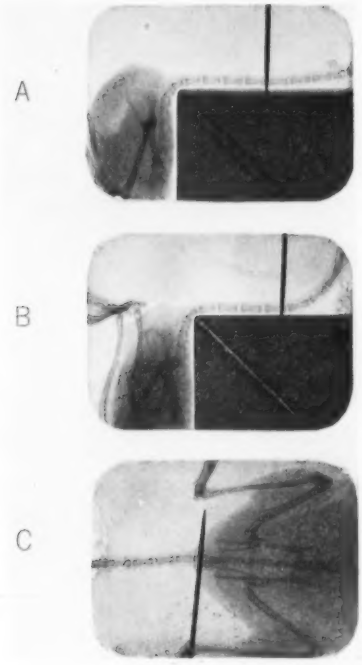

FIG. 5. RADIOGRAPHS, BY DR. A. B. SMITH, SHOWING RELATIONS BETWEEN CAUDAL VERTEBRAE AND POINT WHICH FIGURES AS "BASE" OF TAIL IN MEASUREMENTS OF THIS MEMBER

Two of the vertebrae lying between the pelvic bones commonly belong to the caudal series. (A) Specimen no. 5867, after location of "base" by method described. (B) Specimen no. 5866, in same position (note difference in situation of "base" of tail, possibly due to rigor mortis in this specimen). (C) Same mouse as last, photographed from above. The pin, in the present case, has been inserted to mark the point of the tail which was in contact with the angle of the frame. This corresponds fairly well with the point of emergence of the tail from the trunk.

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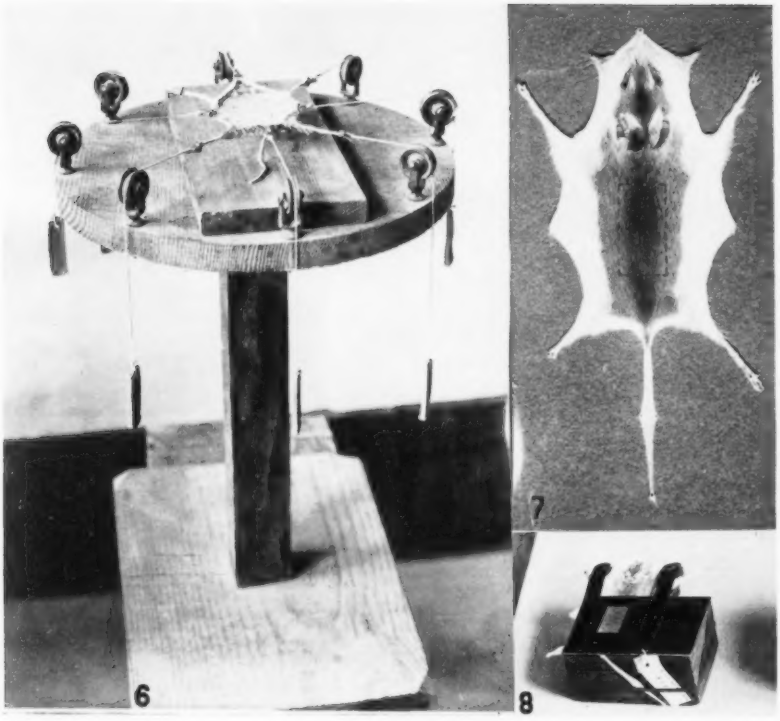

FIG. 6. STRETCHING FRAME, WITH FRESH SKIN IN POSITION
FIG. 7. SKIN PREPARED ACCORDING TO THE AUTHOR'S METHOD
The dotted rectangle represents the area that is viewed through the tint photometer.
FIG. 8. OBJECT HOLDER, WITH SKIN IN POSITION FOR COLORIMETRIC EXAMINATION

Photographs by H. R. Fitch

UNIV. OF MICH.

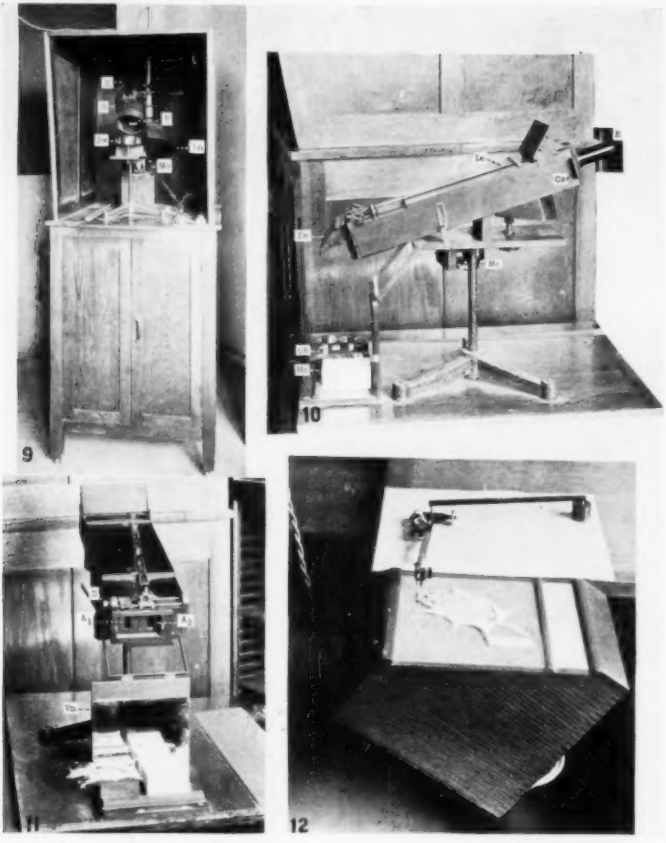

FIG. 9. THE IVES TINT PHOTOMETER, COMPLETE WITH CABINET, FRONT VIEW

The box (B), constituting the main body of the instrument proper, has been tilted upward to expose blending wheel and prism. *E*, eye-piece; *Bw*, blending wheel; *P*, prism; *La*, lamp; *Mo*, motor. The color-screen has been omitted in this figure.

FIG. 10. TINT PHOTOMETER, SIDE VIEW

E, eye-piece; *Cs*, color screen; *Le*, lever; *Mo*, motor; *Im*, inclined mirror; *Oh*, object holder; *Mb*, magnesia block.

FIG. 11. TINT PHOTOMETER, REAR VIEW

The inclined mirror has been removed to show the two apertures, A_1, A_2, which transmit light reflected from the object and the block of magnesia, respectively. *S*, screw, regulating object shutter; *Vm*, vertical mirror.

FIG. 12. POLAR PLANIMETER, AND BOX SERVING TO ILLUMINATE SKIN FROM BENEATH

Photographs by H. R. Fitch

UNIV. OF MICH.

NEWFOUNDLAND SEALS

By Robert A. Bartlett

The following notes on the natural history of the seals have been prepared with the assistance of W. A. Munn, Board of Trade, St. Johns, Newfoundland, who has for years taken a keen interest in bringing together what is known of Newfoundland's cod and seal fisheries. Of the many species of seals in the world, several occur on the coast of Newfoundland. No mention will be made here of the square flipper, the horse head or gray seal, the jar or ring seal, or the bay or shore seal, attention being confined to the two most important kinds, namely, the harp seal (*Phoca groenlandica*) and the hooded seal (*Cystophora cristata*).

HARP SEAL

The harps are present in the largest numbers and are most sought. Young harps captured in prime condition yield the finest quality of oil, which is the principal object of the seal fishery. Adults have a brown patch of hair on the shoulders, supposed to resemble a harp in form, whence the name. They are five to seven feet in length. The color of the hair is dark gray (appearing indigo blue when fresh from the water), fading to paler gray on the back, and white on the belly. The face is dark gray with muzzle almost black, and comparatively long whiskers. The claws are a neutral tint, with a blue shade. The eyes are a liquid brown, large and very beautiful.

The young weighs seven to nine pounds when born and is two feet to two feet six inches in length. It is covered with white stiff wool, which falls off like the fluff from a gosling in about two or three weeks, when it is replaced by hair. When twenty-five to twenty-seven days old and the change to the hair coat is complete, the seal enters the water and is of a pearl gray color, closely covered with small brown spots about as large as a one-cent piece. The young harp continues to be spotted until five years old, when it assumes the indigo blue tint with the brown patch on the shoulders.

The main whelping ground for this species lies some fifty miles east of the straits of Belle Isle, where the tides from the straits and the Labrador current form an eddy, making open water and new ice on which the mother brings forth her young.

The young harp seal is helpless and needs the attention of its mother during the first month of its existence. Being arctic animals these seals

thrive best when it is cold and stormy. They show signs of distress when subjected to the warm weather of a mild season, and grow slowly. If the season be cold with plenty of snow and changeable temperature, with frost, snow and rain, they grow rapidly, increasing in weight from 1½ to 3 pounds daily. They like to be buried in the snow, and eat quantities of it, which, with the exception of the mothers' milk, is their only nourishment. At the age of twenty-five or twenty-seven days the pelt or skin and fat will weigh from forty-five to sixty pounds. A young harp seal begins to lose weight as soon as its hair coat is complete and it takes to the water.

It requires a few days after it enters the water for the young seal to learn to swim and paddle about, and then its mother appears to forsake it. It immediately steers northwest for the land, resting on pans of ice, and very foolishly sleeping in the sun with no protection from its enemies.

As soon as the young reach inshore, they follow north for Baffin Bay, and are supposed to reach there the end of May or June. They do not become breeders before they are at least four years old, although they come south with the school each year as "bedlamers."

HOODED SEAL

The hoods get their name from a peculiar loose skin, which covers the top of the head of the adult male. When he is angry this is puffed out and has the appearance of black rubber. This species is seven to nine feet in length, steel gray covered with irregular brown blotches as big as a 25-cent piece, giving the animal a general rusty black appearance; the belly is whitish, the claws yellow. The young weighs eight to twelve pounds when born. It has a gray back fading into white on the belly. Its hair has a bluish tinge. It does not have a white fluffy coat like the harp seal, but from remnants of such a coat found after birth on the ice, we know that it passes through a similar stage.

Young hood seals usually remain on the ice twenty to twenty-six days to gain strength and prepare themselves for the long journey. They are not as helpless as the young harps, however, and in all probability are capable of taking to the water a few hours after birth. The mother, and sometimes the male, is known to snatch the infant seal from the ice and plunge it into the water in cases of danger.

The main whelping ground of the hood seal lies east or northeast of that of the harp seal on heavier, older ice. This is related to their habit of mounting over the ice when they haul out, whereas the harp prefers to bore up through the ice.

MIGRATIONS

For about three months of the year the hood seals have their home on the east side of Greenland, and the harps on the west side and in Baffin Bay. The ice starts to form in Baffin Bay about September 20, and this appears to be the signal for the seals to get ready for their southward migration. No doubt their food supply gets short about this time, as they start in a very poor, starved condition.

The hoods now meet the harps off Cape Farewell, and move southwest to the Labrador coast, which they reach far north, near Cape Chidley. They have about nine hundred miles to go south along Labrador, swimming close inshore from headland to headland till they reach the straits of Belle Isle. They make this journey in sixty days. They travel comparatively slowly around the islands, the first passing Cape Mugferd about October 25, and their number increases gradually until the middle or last of November. The Labrador men describe them as passing along in strings. The hoods take the outside position and form a parallel line along the coast. Wherever there is found a string of harp seals passing along southward between October and January, the hoods will be found a little to the eastward.

The first string or stream of seals arrives off Battle Harbor about the middle or end of November according to the temperature of the season, and continues till the end of the year, when all have passed south. Seals have been noticed off St. Johns, January 6. The first of the slob ice (dark colored frozen snow on the surface) drifting south passes Battle Harbor the first week in January. The Straits of Belle Isle is an important point in the migration, for here many of the short stout harps turn westward into the gulf and some of the hoods parallel the harps.

However, the main body of seals of both species continue their journey south along the eastern coast of Newfoundland. Most of them make a straight line for Cape Freels and pass south. The old seals have learned to keep well off our southern coast in this migration, and we rarely see them in January now. They pass Cape Race on their way to the Grand Banks, and have been seen as far south as Sable Island Bank.

After being absent from the ice from the end of October for at least two and one-half months, and feeding and fattening at sea, the seals start to move north again early in February. A portion of them are known to enter the Gulf of St. Lawrence by the Cabot Straits, but the main body proceed north around Cape Race and continue until they

meet the heavy arctic ice coming south, about the middle of January. They must rest, and in the absence of ice they turn on their backs, fold their front feet, expand their hind flippers, and sleep with their heads thrown back pillowed on the water. They appear to travel fast as they go north.

About 300,000 seals whelp each year at two points in the Gulf of St. Lawrence, and 500,000 off the Straits of Belle Isle. The two bodies of eastern seals, traveling side by side, the harps inshore, from Cape Race to Fogo Island, generally reach the entrance to the Straits of Belle Isle by the end of February. They are now nearing the season to produce their young, which are to be the sport of winds and currents during the next month.

BREEDING GROUNDS

Harp seals look for a particular kind of ice on which to deposit their young. Extensive ice sheets seldom more than three inches thick are preferred. Their first preparation is to make a suitable hole, so that they can go readily in search of food and get back easily to their young. They make this hole by clawing the ice from beneath. By revolving their bodies round and round by means of their hind flippers, and using the claws on their front feet in a double purchase against the ice, they bore out a sufficiently large hole to permit of going easily on the daily fishing excursions and of returning to suckle the young whitecoat. Besides the "bobbing hole," large enough to enable a seal to mount the ice, there are also blow holes, where it can breathe. Even if these blow holes be frozen over they are an indication to the seal hunter that old seals were there recently.

An old seal fishes all day and returns to the ice in the evening, when the little ones are crying very much like human infants. On the ice the old seals bark very much like dogs, and the howling goes on continually during the night.

Imagine an anxious mother after a hard day's fishing, first finding the ice, which may have drifted a few miles since morning, then selecting its own particular hole out of perhaps 250,000. Since she left, the sealers may have changed the young seals from one place to another, but the mother invariably knows her own offspring, and can not be deceived.

It very rarely happens that fish or food of any description is seen on the ice, and this indicates that most, if not all their food is eaten in or under water.

Because of an occasional scarcity of suitable ice, there are generally two or three patches of the harp seals, but the members of the different patches try to congregate closely within a few miles, where thousands breed together.

At the time that the harps seek young ice, the hooded seals look for rough hummocky Labrador ice on which to deposit their young. This they generally find about thirty miles northeast of where the harp seals breed. They look for ice suitable to mount or leave at their pleasure without boring a hole, and do not congregate in one body, but are scattered in families or small herds about fifty yards apart and often much greater distances.

Such is the general procedure of the harp and hooded seal herds, but with varying seasons they must adapt themselves to such ice conditions as they find and make shift as they may. During the three weeks or a month after the birth of the young, the ice drifts with varying winds and currents, which must be taken into account by the seal hunter who would locate the herds.

After the young seals take to the water, hoods and harps proceed northward independently. The harps remain on the ice off the Labrador coast to shed their coat, but the hoods proceed at once to Cape Farewell and shed their coat on the ice off Greenland.

The family of hood seals consists generally of one male and one female and one young seal; it is very seldom that twins occur. In nineteen cases out of twenty when disturbed by sealers, the female hood will remain and die defending its pup, and sometimes the male will show fight as well.

The old male harp seal is very seldom seen with the female until the pup is eight days old. The female will rarely show fight for its young, but will run for its blowhole when danger threatens.

HALF-GROWN SEALS

Seals of preceding years, not yet adult, are known as "bedlamers," a corruption of *bête de la mer* (animal of the sea). These accompany the old seals on their migrations, but wander farther from the beaten track, and make up the greater part of those caught in nets. The bedlamers of both hoods and harps occupy positions on the ice a considerable distance from the breeding seals. Like the young of other animals they congregate together irrespective of size or color; they are playful, active, inquisitive, and, lacking experience, fearless.

The bedlamers of the harp and hood seals sometimes mingle, but the etiquette which prevents the mingling of adults of these two species is remarkable. The old hoods are wild, fierce and quarrelsome, but for some reason they respect the docile harp, and shrink from close intimacy with them even when by force of circumstances, such as heavy storms and ice jams, they are driven together in close proximity. This is all the more remarkable, as food is most plentiful near the shore, and this position occupied by the harps is not encroached on by the hoods.

HABITS

As seals are rarely caught in January when on the Grand Banks, their food at that season is uncertain, but cod, plentiful there, is supposed to be one of the chief items. Later, when the seal fishery is in progress, they feed principally on capelin and similar fishes. They are partial to herring and also eat considerable quantities of mollusks, shrimps, mussels, and starfish or "five-fingers," for which they must go to the bottom. They usually eat under water, but sometimes bring their fish to the surface, and may consume it lying on a pan of ice. A seal has been seen eating a "turbot." As this fish is only caught on muddy bottoms at a depth of about two hundred feet, it shows to what depths seals may go.

A seal can stay under water probably about twenty minutes. Then it must rise to the surface to renew the air in its lungs, or be drowned. Consequently a seal will not venture rashly under a large body of heavy sheet or packed ice. It will swim around it if possible. A seal is supposed to travel twenty miles an hour for a limited period, so that it may safely venture to travel for six miles under a body of ice, but it seldom does this. It is sometimes believed that seals can find air under the ice, and this would account for their appearing, as they do, in a crack when such occurs in a large sheet of ice, say ten or twenty miles across. Nevertheless, a herd of seals will rarely attempt to go under a body of ice wider than two miles unless it is thin enough for them to break it with their heads. It is curious how they can judge the extent of a body of ice.

An old hood seal has been known to force its head through four inches of slob ice; possibly the hood on its head may act as a buffer on such occasions.

New York City, N. Y.

ON THE SUPPOSED RELATION OF DEER TO CEDARS BORDERING CERTAIN ADIRONDACK LAKES

By Charles Eugene Johnson

[*Plates 20–21*]

Many people who visit the Adirondack region of New York probably are familiar with the fact that the lower branches of the cedars along the shores of certain lakes are dead, the most striking feature of the phenomenon being that the upper limit of the dead branches, or in other words, the lower limit of the green foliage, represents a line perfectly parallel to the surface of the water. Cedars are the only trees affected, and where these stand close together along the shore the line mentioned is so conspicuous that it is likely to attract the attention of even the most casual observer.

This phenomenon was first mentioned to me several years ago, before I had visited the Adirondacks, by a friend who had been told by guides and others that it was the result of the browsing of deer in winter. In the summer of 1921, while engaged in a study of the beaver for the Roosevelt Wild Life Station, my first opportunity came to see a number of Adirondack lakes where this phenomenon was displayed. Like my friend I inquired of guides and other local residents as to how they explained the belt of dead branches, and I received the same answer: That it had been caused by the browsing of deer in the winter time.

According to this explanation the deer are in the habit of walking along the shore, on the ice, and browsing on the green foliage of the cedars. Now, the lower limit of the green foliage is much too high for adult deer to reach on all fours, but it is explained that the animals rear up on their hind legs, and thus the upper limit of the dead belt represents the utmost reach of the deer. Yearly browsing in this way has, according to the popular notion, gradually killed the entire lower story of branches, and the parallelism of the upper boundary line is accounted for by saying that, standing on the ice the deer can reach up to this fixed height, all around the lake.

When I first saw the condition of the cedars bordering one of these lakes, certain rather obvious facts led me to question seriously in my own mind whether the popular explanation be the correct one, and indeed whether after all deer had in any way been responsible for the origin of the dead belt. Since then I have taken note of a number of lakes where the same phenomenon exists, with the result that I have

become convinced that the cedar line has not been brought about by the browsing of deer, and it is my purpose in this article to present certain facts and arguments which seem to me to confirm this view.

As the phenomenon began to interest me I made a search through available literature for possible references to the subject, and then discovered that the popular explanation was not without support of authority. Dr. C. Hart Merriam, in his Mammals of the Adirondack Region (1886, pp. 110–111), goes into a considerable discussion of the phenomenon and points out "conclusive evidence" that the dead belt has been caused by the browsing of deer. The same peculiar condition of the cedars had, however, been noted earlier by Verplanck Colvin, in the course of his Adirondack survey (Topographical Survey of the Adirondack Region, Third to Seventh Report, 1874–79, p. 162), and he confessed that he had been deeply puzzled by the appearance of the cedars around some of the lakes until he discovered what to him seemed to be the explanation of the mystery, namely, the deep snow-drifts which in some winters lay piled along the shores. No other references to the phenomenon have come to my notice, and since Colvin's explanation and Merriam's differ so widely, and since Merriam goes into considerable detail and emphasizes the conclusiveness of the evidence which proved to him that deer were the cause, it will be desirable to quote these two authors in full.

Colvin's brief reference runs thus:

> Another problem was also solved. The open, smooth surface of the lake was undoubtedly to be attributed to the wind which swept it clear of the snow, driving it into the forests on either side, where, near the shores, great drifts accumulated. This again in its turn solved another mystery; the cause of the death of all the lower branches of the cedars (arbor-vitae) growing along the lake shores. This had been observed in summer, and was unaccountable. Now it was evident that the deep snow drifts buried these limbs, and in some unfavorable season, becoming compact and icy, had killed the enclosed evergreen foliage.

Says Merriam:

> A large number of the Adirondack lakes are heavily bordered with a dense frontage of arbor vitae (here called 'white cedar'), which so overhangs the water that the lower limbs barely clear the surface. Around many of the lakes all the lower branches, up to a certain height, are dead, so that on viewing the shore one is struck with the strange appearance of a sharp-cut line, about the height of a man's head, extending partly, or entirely, around the lake. Above it the dense foliage presents an almost continuous and unbroken front, inpenetrable to the eye, while below it not a green sprig can be seen, the dead limbs and branches remaining in the form of a broad belt.

The cause of this phenomenon long remained a mystery, and many and amusing theories have been advanced for its explanation. It has been supposed that some unusual and unknown agency operated to produce a great overflow of these lakes, and that the present green line indicates the high-water mark of this unrecorded inundation, the branches below it having been killed by the water or ice. Were there no other reasons for disbelieving this hypothesis, its absurdity is demonstrated by the fact that on many of the larger lakes the line is confined to one side. The only other theory, so far as I am aware, that is worthy of refutation, was advanced by no less distinguished a gentleman than Mr. Verplanck Colvin, Superintendent of the Adirondack Survey. Mr. Colvin's theory is, that the snow which is blown off from the ice, on some of the larger lakes, and is sometimes piled in drifts in certain places along the borders, buries the lower limbs of the cedars; and he thinks that this snow "in some unfavorable season becoming compact and icy, had killed the enclosed evergreen foliage." The fallacy of this view is proven, I think, by the following facts: 1st, branches on the opposite or shore side of these very trees are usually alive and green, which could hardly be the case were the drift theory true; 2d, the line is often most strongly marked on the shores of ponds that are too small, and too closely hemmed in by hills, to afford the wind a chance to drift the snow about their borders; and 3d, the foliage line is, in all instances where I have observed it, perfectly straight, and exactly parallel to the surface of the water, which could not possibly be the case were it caused by irregularly drifted snow.

Moreover, it is now an ascertained fact that the green line is the result of the wintering of Deer along the shores where it exists, and the evidence on this head may be summed up as follows: In the first place, it is absent from at least half of the cedar bordered lakes, and is only found, of recent origin, in localities where Deer are known to winter. On some of the larger lakes it is confined to one shore and sometimes to a single deep bay, while the cedars about the rest of the lake remain unmarred. Furthermore, it is a fact, which can be verified by any one willing to take the trouble, that where the Deer still winter in these places the snow which covers the ice is literally trodden down by them, a well beaten path follows closely the outline of the shore, and the stumps of newly broken branches may here and there be found. The height of the line shows the distance that a full grown Deer can reach when standing on the snow and ice. And finally, trustworthy witnesses affirm that they have observed the Deer standing on the ice in the act of browsing upon the low branches of cedars overhanging the lake. I regard all this evidence as conclusive.

After reading Merriam's account it may seem the height of temerity to reopen this old question which apparently was effectually disposed of long, long ago, and I should be the last to do so had I not in a moment of idle curiosity noticed certain things which appeared out of harmony with the current explanation. In his account Merriam unfortunately does not clearly distinguish between facts which he himself may have observed or verified and those which may have been accepted on the testimony of others. That the phenomenon had, as Merriam states,

long been a mystery seems in itself rather significant, for if the explanation given were the correct one it should have been sufficiently apparent long before, and there should have been little mystery about it. It is likewise not without some significance that Colvin had failed to notice deer sign in connection with the mystery, and that he apparently had not heard of deer as being a cause, although be had guides and other Adirondack residents in his employ. But the deep snow theory fails.

The excellent description given in Merriam's first paragraph fits exactly conditions as they may be seen about some Adirondack lakes at this very day. But if it was true, as he states, that the dead belt on some cedar-bordered lakes was confined to only a part of the shore, then that is important—though not in the sense that it would have to be interpreted as confirmation of the correctness of the browsing theory—and is different from conditions which I personally have seen at the present time. On lakes where the line existed at all I found it absent only on those parts of the shore where cedars were lacking; lone cedars standing among other species of trees on the waterfront were found to be affected exactly as were those forming a continuous fringe. Not one had escaped. Another statement by Merriam which I have been unable to verify in those cases which I have seen is, that the limbs on the shore side of the cedars were usually alive. In no instance have I seen this to be true; the limbs were dead and dry all around and to the same level. And further, I have met with no instance where the phenomenon was of recent origin. I mention these points for obviously they have an important bearing on the problem. Without mentioning at this time one or two other points in Merriam's account which also might be open to question, I will now present the evidence and the reasons which appear to me to throw a good deal of doubt upon the browsing theory as a true explanation of the phenomenon under discussion.

1. If the lower branches of the cedars have been killed by the browsing of deer, how, it may be asked, have these branches been able to attain such size, number, and density as in reality exists (e.g., fig. 1) in many instances? The branches should have been browsed off as they grew. Deer surely have inhabited the Adirondacks for hundreds of years and there is little reason to suppose that their food habits in that region in the more remote past were, so far as cedar is concerned, any different from what they were forty years ago or at the present day. If therefore at the time that Merriam wrote or even at the present day the animals browsed so extensively on cedar as they have been supposed to do the branches could hardly have attained the size and age actually

found. The new shoots would have been browsed off yearly and there would have been no mass of dead twigs such as we see today, or as Merriam described them forty years ago. One might even say that there would have been no cedars at all along the shores for the young trees would have been browsed to death.

2. As may be seen in the photographs the dead branches show none of the characteristic marks of browsing which are so well known on cedars growing, for example, in pastured areas; or on balsam fir, to mention another species of evergreen on which deer feed more or less in the Adirondacks and elsewhere. Where browsing occurs the smaller twigs are lopped off and only the larger branches and limbs remain, and new shoots keep growing out yearly, giving to the whole a very characteristic appearance. On the cedars in question there are on the contrary dense masses of smaller branches and twigs remaining, the terminal twigs being in some cases not much thicker than the lead in an ordinary pencil. True, on many of the trees lower branches are almost wholly lacking, but the smooth trunk shows that few have existed. The same condition can be seen often on cedars growing where deer are not found. But the great mass of small branches and twigs could hardly have existed in conditions where browsing is supposed to have been so intensive and persistent as to have killed such an entire belt of limbs. In the existing condition all sizes of dead branches are present on the same tree, often in great profusion, and these branches have exactly the same appearance as the masses of dead branches on cedars which have been killed by other agencies, as for example those which have been drowned out, or uprooted, and which no one will contend have been killed by browsing.

3. The age which great numbers of the dead branches had attained is considerable. For example, a larger branch which I selected at random measured one and three-eighths inches in diameter, and I was able to count at least one hundred and twenty annual rings. A smaller one measured five-eighths of an inch in diameter and showed at least sixty-six rings. Many of the larger branches would measure two inches or more in diameter. In a deer-inhabited region, were these animals so addicted to the cedar-browsing habit, it is quite unlikely that any of these lower branches, all within easy reach, would have survived upwards of a century and a half. If half the cedar-bordered lakes of the Adirondacks were unaffected, as Merriam states, that fact is not satisfactorily explained by an assumed absence of deer from their vicinity, for movements of deer doubtless occurred in the past

as they do at the present day, and new pasturage would have been sought, for the uppermost twigs in all parts of the dead belt where I have examined them have been dead and dry for years, and since this evidently was true also at the time that Colvin and Merriam wrote, it will be admitted that there existed sufficient inducement—with the green edge practically out of reach on the remaining cedar-bordered lakes—for the deer to seek both far and wide for this supposedly favored food.

4. In many instances I have found the line passing uninterruptedly through tangled groups of leaning cedars, such as those shown in figure 2, for example, and here the browsing theory fails entirely to function. It will be granted, I believe, even by the most enthusiastic supporter of the browsing theory that in such situations a deer could gain access neither on all fours nor on twos, but only by assuming the form and attributes of a squirrel.

5. All the evidence which I personally have seen, as well as the information which I have obtained from others in regard to the lakes with which I am familiar, shows that the lower edge of the green has for many, many years remained fixed at the present level. Therefore, to accept the browsing theory one must necessarily assume that through all these years, every winter, the deer have walked on the ice along the shore and kept the line trimmed close, overlooking not a single tree nor a single branch. Had they not, the line, being unequally trimmed, would in the course of a few years have become irregular. When one further bears in mind that the upper edge of the dead belt is much too high for the deer to reach on all fours, but only by rearing up on their hind legs—a position hardly possible for complete trimming—and when one realizes that on some of these lakes the cedar belt may reach a length of one or two miles and perhaps more, then, to use a current expression, it all looks like a pretty big contract.

6. That deer in the Adirondacks in winter or at any other time feed to any considerable extent on cedar is in itself a question by no means well established. There is no intention here to question the fact that deer occasionally eat the foliage of cedar, just as they eat more or less of green hemlock and of balsam fir, but except in periods of stress it is doubtful whether the animals browse to any considerable extent on cedar. That at least is the only conclusion I can draw so far as my own observations go, and one old Adirondack hunter and guide who lived near two lakes where the dead cedar belt was especially well marked and who had himself explained to me that this was the result

of the browsing of deer, stated on another occasion that the animals did not usually eat cedar; that it was only during the coldest days in winter that they seemed to touch it. To use his own words, they ate the cedar foliage "only when it was crisp"! Further evidence that deer do not generally browse on cedar in this territory will be brought out in the following paragraph.

7. This past summer I had an opportunity to examine in some detail the cedars bordering Mohegan Lake, in northern Hamilton County, about the shores of which the deadline is remarkably well defined (see photographs). When I reached the outlet of this lake I discovered that the dead belt rapidly narrowed down and then disappeared. Although the lake itself is deep the water at the outlet is shallow, being only about 15 inches deep at that time, and perhaps 25 to 30 feet wide. Several fallen cedars lay flat across the stream here, no higher than I could easily step over them. On the banks grew cedars with dense green foliage hanging within about three feet of the surface of the water; and there was no belt of dead limbs below the green. On a fallen cedar in the middle of the stream were a number of living upright limbs about three to four feet high. These limbs had a thrifty crown of green, but the lower part of the stem was devoid of branches or twigs, so that in appearance they resembled limbs growing higher up on leaning trunks found here and there on the shore of the lake, as for example those shown at the extreme right in figure 3. In addition there were a number of young cedars only a foot or two high growing on rotten logs which lay across the stream at this place; these were more bushlike in form and lacked dead twigs.

Now, the significant feature about all these low-growing cedars was, that they showed no evidence of browsing although all were within easy reach of deer on all fours; and only a few steps away was the belt of cedar limbs where browsing is supposed to have been so persistent and close that every twig had been killed.

8. In regard to the height of the lower edge of the green foliage above the surface of the water, Merriam states that it was "about the height of a man's head." This past summer when, from heavy and frequent rains, the water level was somewhat higher than usual, I found the lower edge of the green foliage at Mohegan Lake to be 7 feet, and at the neighboring Handsome Pond where I made measurements on the same day, it was 6 feet 10 inches, or practically the same height above the surface of the water. Since the average height of adult male Adirondack deer doubtless falls below 3 feet 5 inches at the shoulder

it is clear that, as before suggested, deer can not reach the upper edge of the present dead-limb belt without rising up on their hind legs. This being true, and since deer can not maintain the two-legged attitude without resting their fore feet against some support, one should find considerable evidence of pawing among the dense mass of dry twigs often present in this dead belt. Such evidence I have failed to find.

Having thus attempted to prove the fallacy of the notion that deer have been responsible for the origin of the dead belt of the cedars, it may be suspected that I have a better explanation in mind. Unfortunately I have nothing of a very definite nature to offer, and moreover, the question does not appear to be one for the zoologist to answer, but rather one for the plant ecologist and physiologist. It may nevertheless be permissible to venture a few remarks on the subject of cause or causes.

Since the agency of deer must be excluded, what other possible agencies might have produced the condition described? First of all, of course, one thinks of high water; but, as intimated by Merriam, no such high water level has apparently been recorded for the region. However that may be, a fatal objection to such an explanation, it seems to me, is the sharp line of demarcation between the dead and the green branches, for even if high water at some past time had killed the lower branches it would seem that the adjacent living ones would in time have overgrown and overhung the dead belt so as to obliterate the original sharp boundary line. This sharp line, the perplexing feature about the phenomenon, has, so far as all the evidence goes, been maintained uninterruptedly for a very long time, and for this reason it would appear necessary to seek for a cause or a set of causes among some physical factors of the environment which are constantly in operation and which are concerned with the physiological requirements of cedars growing in such particular situations. Doubtless the most important, though not necessarily the only, factors concerned are those of light, temperature, and moisture, together with certain sensitiveness peculiar to the cedar itself. With regard to light alone, it is possible that these low branches suffer a deficiency both in the quantity and quality of the light rays which reach them. When one notes the generally conical shape of the cedars, and the fact that the deadline falls at the broadest part of the tree, the idea of shading as a factor appears not wholly without basis. A deadline seems to have developed below which the minimal requirements for life are wanting. So far as any facts are known to me there would be no objection to assuming that the edge of

FIG. 1. CLOSE VIEW OF A PORTION OF THE DEAD LIMB BELT OF CEDARS ON THE EAST SHORE OF MOHEGAN POND, ADIRONDACKS. LOWER EDGE OF GREEN FOLIAGE ABOUT SEVEN FEET ABOVE WATER SURFACE

FIG. 2. DEAD LIMB BELT PASSING THROUGH TANGLE OF LEANING CEDARS ON EAST SHORE OF MOHEGAN POND. BRANCHES OF DEAD BELT INACCESSIBLE TO DEER IN SUCH SITUATIONS

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FIG. 3. LEANING CEDARS SHOWING LOWER EDGE OF GREEN FOLIAGE AND DEAD LIMB BELT, ON EAST SHORE OF MOHEGAN POND. NOTE FORM OF THE TWO LIVE BRANCHES AT EXTREME RIGHT

FIG. 4. ENLARGEMENT SHOWING A PORTION OF THE CEDAR LINE ON THE WEST SHORE OF MOHEGAN POND, AS SEEN FROM THE WATER

UNIV. OF VICT.

the green was at one time lower down—for nothing is more certain than that the belt of dead branches once was living!—and has, imperceptibly perhaps, been creeping upwards to a point where it may possibly remain fixed during the life of the tree. That is, when these cedars were smaller the lower branches were living, but as the trees continued their slow growth the lowermost branches gradually died, and this exceedingly slow process continued through the years until a level was reached above which the minimal requirements of life were met, and there the line became fixed. Since the upper edge of the dead belt is exactly parallel with the surface of the water it appears as if the plane of the lake surface had played a controlling part. Whether it may be possible that the lake surface by virtue of its reflecting capacity, for certain light rays, for example, or in some other way has controlled this parallelism is not for me to say. The whole problem is one that doubtless will yield to attack by the modern instruments and methods of the plant ecologist and physiologist.

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WINTER FOOD OF COTTONTAIL RABBITS

By John B. Todd, M.D.

The territory included in this study is chiefly the rim of Green Pond, on the Clark Reservation (elevation about 800 feet), about three miles from Syracuse, New York; and a wood road and trail east of White Lake (elevation 650 to 700 feet), about five miles from Syracuse. This trail crosses the valley and the outlet brook from White Lake, up through the woods to the top of the cliffs, and is not over a half-mile long. Each locality was visited a number of times during the winter and spring of 1926. Also a single visit was made to Labrador Hill (elevation 1865 feet), to Bar Ontario (elevation 248 to 280 feet), and to St. Mary's Pond (elevation 544 feet).

From the work on trees and shrubs, tracks in the snow and droppings, it is evident that there is a large population of rabbits in each place; nevertheless, but a single cottontail was seen, and all that was seen of that one was a glimpse of its tail. According to the records there were 13,009 hunting licenses issued in this county (Onondaga) in 1925.

The rabbit is timid and retiring; by day it hides in nooks and corners, under brush and shrubbery, coming abroad to feed mostly at night. It is hunted by eagles, foxes, weasels, hawks and owls, and men; but depending upon its keen hearing, its eyesight and its legs for safety, it manages to prosper.

During the severely cold and stormy days it is in comfortable seclusion. It is a nocturnal worker, and as soon as the weather moderates it sallies forth to look for food; that is its chief work and recreation. The ideal time to see just what a rabbit will do in one night is after a light snow has fallen on a hard crust. Then is the time to go into the woods and follow its tracks, untangle its route if you can! If you look sharp you will see where it stopped and cut and ate a basswood sprout; on a little way it had a bite of the bark of a cedar; through an open space it helped itself to a tidbit from a thimbleberry cane. The shrubs and small sprouts are cut as smooth with its chisel teeth as one could do with a sharp knife, and they are all cut at an angle of approximately forty-five degrees.

To walk along a trail bordered by osiers, basswood sprouts and berry bushes and notice that many of all of them have been severed as clean and smooth as could be done by a person with a knife, and that the cutting is all at the same angle and at about the same height above the ground, seems almost incredible. But when you track the worker and

observe that it has stopped here and there and cut and ate the sprouts and canes, and left droppings, the evidence is conclusive.

The cottontail's bill of fare during the winter includes a long list of trees and shrubs. Its summer dietary is another story. Its winter food in the localities examined has been found to consist of the bark and small branches, stems, or shoots of the following plants:[1]

1. Staghorn sumach	*Rhus typhina*	A[2]
2. Sugar maple	*Acer saccharum*	B
3. Wild apple	*Malus malus*	C
4. Prickly ash	*Xanthoxylum americanum*	B
5. Sweet clover	*Melilotus alba*	D
6. Black raspberry	*Rubus occidentalis*	D
7. Wild red raspberry	*Rubus strigosus*	D
8. Purple-flowering raspberry	*Rubus odoratus*	D
9. White cedar	*Thuja occidentalis*	C
10. Blue beech	*Carpinus caroliniana*	E
11. Basswood	*Tilia americana*	D
12. Evening primrose	*Oenothera biennis*	E
13. Red maple	*Acer rubrum*	C
14. Black birch	*Betula lenta*	CD
15. Red osier dogwood	*Cornus stolonifera*	D
16. Thorn-apple	*Crataegus coccinea*	C
17. Bitternut	*Carya cordiformis*	C
18. Choke pear	*Pyrus communis*	C
19. Slippery elm	*Ulmus fulva*	D
20. Cork elm	*Ulmus racemosa*	C
21. White elm	*Ulmus americana*	C
22. Shrubby bittersweet	*Celastrus scandens*	A
23. Bladder nut	*Staphylea trifolia*	E
24. Choke cherry	*Prunus virginiana*	C
25. Wild red cherry	*Prunus pennsylvanica*	C
26. Wild grape	*Vitis cordiformis*	C
27. American barberry	*Berberis vulgaris*	B
28. Witch-hazel	*Hamamelis virginiana*	C
29. Hop hornbeam	*Ostrya virginiana*	C
30. Sweetbrier eglantine	*Rosa rubiginosa*	E
31. Alternate-leaved dogwood	*Cornus alternifolia*	D
32. Round-leaved dogwood	*Cornus circinata*	D

[1] A collection of samples of all these rabbit-gnawed trees and shrubs has been deposited at the Roosevelt Wild Life Experiment Station, Syracuse, New York.

[2] A = bark and soft wood extensively eaten.
B = bark only is extensively eaten.
C = bark only is moderately eaten.
D = small branches and shoots are extensively and entirely eaten.
E = small branches and shoots are sparingly eaten.

33. White ash	*Fraxinus americana*	E
34. Black locust	*Robinia pseudoacacia*	E
35. Shagbark hickory	*Carya ovata*	E
36. Hemlock	*Tsuga canadensis*	C
37. Quaking aspen	*Populus tremuloides*	E
38. Hobblebush	*Viburnum alnifolium*	E
39. High blackberry	*Rubus argutus*	A
40. Red oak	*Quercus rubra*	C
41. American beech	*Fagus grandifolia*	B
42. Striped maple	*Acer pennsylvanicum*	C
43. Bush honeysuckle	*Diervilla diervilla*	A
44. Meadow rose	*Rosa blanda*	E
45. Meadowsweet	*Spirea salicifolia*	E
46. Golden-rod	*Solidago* sp.?	E
47. Wild black cherry	*Prunus serotina*	E
48. Speckled alder	*Alnus incana*	E
49. Golden osier	*Salix blanda*	E
50. Crack willow	*Salix fragilis*	E
51. Withe-rod	*Viburnum cassinoides*	E
52. Glaucus or pussy willow	*Salix discolor*	E
53. Blueberry	*Vaccinium vacillans*	E
54. Pin oak	*Quercus palustris*	D
55. Shad bush	*Amelanchier canadensis*	E
56. Green ash	*Fraxinus pennsylvanica*	E
57. Mountain maple	*Acer spicatum*	E
58. Spice bush	*Benzoin aestivale*	E
59. Silky willow	*Salix sericea*	E
60. Shining willow	*Salix lucida*	E
61. Bebb or beaked willow	*Salix bebbiana*	E
62. High-bush blueberry	*Vaccinium corymbosum*	E
63. Leather leaf	*Chamaedaphne calyculata*	E
64. Sweet viburnum	*Viburnum lentago*	E
65. Low shad bush	*Amelanchier stolonifera*	E
66. Black chokeberry	*Aronia melanocarpa*	E
67. Panicled dogwood	*Cornus candidissima*	E
68. Prickly gooseberry	*Ribes cynosbati*	E
69. Maple-leaved viburnum	*Viburnum acerifolium*	E
70. Millspaugh's blackberry	*Rubus canadensis*	D
71. Chestnut oak	*Quercus prinoides*	E

Many from this list of plants that form the winter food of the cottontail, have more or less active medicinal properties, according to old books. Thus barberry is a gentle tonic and laxative. Prickly ash is a stimulant, producing a heat in the stomach. When the bark is chewed it produces a burning sensation in the mouth. Cottontail rabbits eat very generously of sumach bark and the outer wood. Sumach is an acid astringent, and contains a glucocide from which tannin

is derived. The chemical structures of starch, glucose and tannin are somewhat alike in containing carbon, hydrogen and oxygen. It may be an advantage for some plants to store energy in the form of the glucocide tannin, which by a reverse reaction may be utilized as glucose. The early chemists obtained glucose from sumach and perhaps rabbits can do the same. Dogwood is credited with being a tonic and stimulant. The early settlers in this country used wet packs of dogwood leaves in bruises, wounds and infections. Hickory bark has been used in dyspepsia. The climbing shrub we call bittersweet is credited with being an emetic and narcotic; it must be something that cottontails especially relish, for they eat it freely. Witch-hazel has been used for almost everything; but rabbits eat it sparingly, perhaps to eke out a scanty winter food supply. Our Revolutionary forefathers used the powdered bark of benzoin as a substitute for spice. The only part of the sweetbrier rose taken by the rabbits is the extreme tips of the branches where the thorns are mostly absent. Slippery elm is stated to be nutritious, and from the quantity eaten by rabbits it is probably so for them. In one case, someone had cut and removed a five-inch sugar maple tree, leaving the limbs and branches. The rabbits made a grand feast of the bark, which was almost entirely removed from these. This occurred early in the spring while the ground was still covered with snow. Perhaps they got a taste of sweet sap in the inner bark, and all the clan rallied to the banquet. Birch also has a sweetish sap and in late spring innumerable flies are attracted to the stumps of birches cut late in the winter. Children in the country frequently eat the tender shoots of raspberry, and rabbits are extremely fond of the canes of various species of raspberries and blackberries.

It is surprising to note the number of hardwood trees that contribute to the rabbit's diet, including various oaks, hop hornbeam, water beech, hard maple, black birch, beech, elm, apple, pear, thorn, and prickly ash. There is just a hint of a great future for this weak, insignificant animal that includes oak, ironwood, hickory, etc., in its daily ration. If it continues on this diet for a couple of million years it may become king of the beasts! Look at the relative position in the animal world of the horse and the mastodon two million years ago!

The rabbit's food must be material that will provide the carbohydrates, the proteids, the hydrocarbons and mineral salts needed to build and maintain its bodily vigor. The trees and shrubs in the temperate zone accumulate during the summer a reserve supply of food materials for the next season's growth; this is stored during the

winter in the buds and inner bark. The carbohydrates are in the form of starch, the proteids in the plant juices, and the fats and oils in the cells. It is this concentration of food materials in the cells and juices that protects the tree or shrub from frosts; and it is this stored food in the bark and buds that comprises the rabbit's subsistence in winter.

The relation of rabbits to their environment may be expressed by the statement that "where their food grows, there is their home,"—provided they can find places to hide, for it is as important that they obtain adequate protection from their enemies as that they find food.

There is a wild lot, of three or four acres, situated on a hillside which is a picture garden of wild shrubbery. Surely, one would expect to find plenty of rabbits' work in such a place. Yet a diligent search failed to show the slightest indication of the presence of either rabbits or mice. The soil of this hillside is gravelly clay, and the shrubs grow so thickly that there are no wild flowering plants or grass. The thicket cuts off all the sunlight. There are no fallen old trees, no stone heaps, no rocky ledges, no brush piles, and no homes for the rabbits; plenty of food but no protection, no place to hide away from their enemies. The four-foots have a wise discretion and avoid this baited trap.

Inferring from observations of the locations of their tracks and work, rabbits flourish best in a rocky, wild land that has scattering trees, with open spaces filled with abundance of brush, briers and weeds. The slashed-over woodlot that is not included in pasture land provides the ideal home for them. One would hardly think that a flock of sheep or a herd of cattle would exterminate rabbits from a given location sooner than the dogs and hunters. This the flocks and herds do by eating practically all the food. Sheep, especially, will consume in the summer all the small shoots and sprouts that provide winter food for the rabbits. Cows also love to crop the tender leaves and branches of the shrubs and brambles that grow in the pastures. The thorn-apple is about the only shrub that can flourish in a pasture, and even this has its tender sprouts eaten, the cattle pruning it into fantastic shapes, until as the years pass the shrub spreads out so that they can not reach the central part, which thereupon shoots up like a spire.

Basswood sprouts are about the largest a rabbit can cut off. It loves to cut the slender birch shoots, and one can see the next year where two or three new sprouts have grown and in turn been cut the following winter, and so on for a number of years until the body of the birch the size of one's finger is topped only with a knobby crown. Small

sprouts of dogwood are cut; and nearly all wild red raspberries in a rabbit community have their tips pruned, which probably improves the crop of fruit. At Bar Ontario the berry bushes seem to be the principal food used, only short stubs of the high blackberry being left. These animals do not gnaw anything much larger than three-fourths of an inch in diameter. It is difficult to see that rabbits do any real damage in the "wild lots" where they live, though they sometimes damage young fruit trees.

Bar Ontario, affording an environment contrasting with those considered above, was carefully examined for signs of rabbits. It is a strip of sand dunes and "wind gaps" one-fourth mile wide and four miles long, that separates the bay called Sandy Pond from Lake Ontario. The northern end joins the mainland at the town of Ellisburg, Jefferson County, while the southern end is cut by an inlet. It is more or less wooded with trees rather stunted in growth and with vines and brambly shrubs. On the west, the waves of the lake pound the sand dunes, while the sand is drifted towards the bay by the prevailing northwest wind, producing a flat beach a few rods in width upon which grow scrub popple, tag alder, tall beach grass, rushes, and cat-tails. In the summers there is plenty of food and cover for rabbits and one can start them up easily. But from the evidence of their work there can be very few there in winter. Black and red raspberry bushes show the greatest amount of cutting, but this appears to have been done only the fall previous. There are no indications of recent work anywhere,—not a bit of bark removed from any tree or shrub, nor any indications of recent cutting of sprouts. But there are many enemies of rabbits at Bar Ontario, from sportsmen to bald-headed eagles; so when winter comes and destroys the vegetation that afforded a cover for them, they probably migrate to the mainland forest. Bar Ontario is a beautiful place in summer, the home of birds and flowers, but bleak and terrible in winter and evidently no place for a wise rabbit.

In making this study the work of mice has been frequently observed. One soon learns to distinguish their work from that of rabbits by the very much finer tooth-marks and by other characteristics. Standing on the ground or snow, rabbits always gnaw around the bush, while mice work standing on or climbing around, and can eat in any position as is plainly indicated by the direction of their tooth marks. One can see the work of mice on sumach as high as six feet from the ground. On Labrador Hill the meadow mice have thousands of roads in the matted grass, leading to the wild apple and thorn shrubs which are

left with their lower branches whitened skeletons. The white-footed or deer mice have worked on apple and maple, removing the hard outer bark and getting at the cambium or inner growth. Very small twigs are cut into pieces from one to four inches long and then left denuded of every particle of bark. In this locality there are indications of a very large mouse population.

The more good-for-nothing a "wild lot," the better it is for study and observation of the native plant and animal life. Every city, town, village, and country neighborhood, should have such a good-for-nothing wild lot—a tract of "waste land"—a refuge for all wild life, for birds and mammals, for flowers, ferns and weeds. A place where everything that lives and grows by just being let alone could have a home, and where tired and weary people could go and look on, and where inquisitive and active ones could go and learn how the wild things live.

Syracuse, New York.

THE COLORADO PIKA IN CAPTIVITY

By L. R. Dice

During the third week of July, 1926, three pikas (*Ochotona princeps saxatilis*) were trapped alive at Willow Park, in Rocky Mountain National Park, Colorado. All were taken at an elevation of about 10,600 feet, or about 500 feet below timberline. I found it not difficult to trap pikas alive in a trap having wire screen tops and sides. The traps were set on the rock slides at places pikas had been seen to frequent, or where fresh sign was abundant, and no success was had in setting traps at random on the rock slides. The most effective bait was green willow leaves, and the animals seemed not at all attracted to rolled oats or other common rodent baits. Altogether I trapped four pikas alive in these traps in a few days on small rock slides where the animals were not at all common. However, rain storms in the late evening or night killed two of these animals after their capture before I could visit the traps. Another very young pika, about one-quarter grown, was caught by one leg in a snap mouse-trap set by a log in the Engelmann spruce forest about forty meters from the nearest edge of a rock slide. The broken leg was amputated and the pika survived.

The three living pikas were shipped to Ann Arbor, Michigan, where they were kept in cages in my laboratory. One proved to be an adult female and gave birth to a litter of three young in August. These little ones died before I returned from the field to Ann Arbor, and I can give no statement as to their condition at birth. The other two animals were males.

These pikas remained fully active all winter, eating freely all the time. The temperature of the room in which they were kept averaged about 65°F. during the day, but became much colder at night, when the steam was turned off. In January and February the pikas became almost entirely gray in color, with hardly a trace of the summer buffy tints. About March 1 they began to change again to the summer color. In this spring molt a buffy tinge was first noticed on the frontal region of the head and along the sides of the body. In neither fall nor spring molts was there any sudden change of color, nor any sharp molt line, but the pelage seemed to be replaced by a few hairs at a time.

On March 1 the female and the older male were turned together for a short time, by opening a door between their cages. They were quite excited and ran about and called a great deal, but did not mate. Beginning March 10, the two were left together constantly night and day for about a week. They seemed to behave peacefully at first, but one morning it was found that the male had torn all the hair off the back of the female, the skin of her back being bitten and scratched all over. They were immediately separated, and after a time the female recovered and grew a new coat of hair. The female proved not to be pregnant. Later some attempts were made to mate the female with the young male, now fully mature, but at each attempt the female attacked him with such vigor that they had to be separated to save his life. No success, therefore, was obtained in breeding these pikas in captivity.

Although not apparently vicious nor quarrelsome when being handled by man, yet these observations indicate that the animals in their native haunts may indulge at times in fierce fights among themselves. My meager observations of them on their native rock slides would lead me to believe that they are rather solitary, each with its own particular range, and it would not be surprising to find that the winter store of food is an individual possession defended against all others of their own kind. However, it is possible that a mother and her last brood of young might remain together during the winter.

For food in captivity these pikas preferred hay, either timothy, clover,

or alfalfa. They were fond of some kinds of green vegetables, such as lettuce. They also learned to eat whole oats, but were not especially fond of them.

The characteristic call of these animals was given mostly when they were excited; or more particularly when they were somewhat alarmed, but not quite so frightened as to retire to their nest. It was not given frequently; often several days or weeks would pass without its being heard during office hours.

In intelligence, I would not class these animals high; they are not nearly so intelligent as a cottontail rabbit. Neither are they so active nor agile. Occasionally one would escape by making a sudden dash around the cage while the door was open for feeding them; but its getting through the open door seemed to be an accident, and the animal would tumble headlong to the floor, a distance of two to four feet. They never seemed to be injured by these falls. They were easily recaptured by being driven toward a live trap set along a wall. They never learned to avoid a trap, but would plunge completely through and always bump their nose on the rear wall. This makes me doubt if their eyesight is very keen.

March 30, 1926, the oldest male pika was found dead in his cage in a very emaciated condition. On examination it was found that the cheek teeth on one side, both upper and lower, were greatly elongated, growing outward, so that they did not close together, thus making the chewing of food difficult or impossible. I could detect no injury to the skull that would cause the teeth to grow so abnormally, though it is possible that he received some injury in fighting with the female.

The female and the remaining male both died on July 21, 1926, during a period of hot weather, reaching on that day a temperature of 97°F., according to the Weather Bureau record. As the animals were kept in a room fully open to the outside air it is probable that the cage temperatures were closely similar to those recorded by the Weather Bureau station on a nearby building. This would seem to indicate that the pika is unable to endure high temperatures, and for this subspecies the maximum limit is probably under 95°. I have often noticed in the mountains that during clear, hot days the pikas are not active except in the evenings and mornings, when the temperatures are not very high on the rock slides. The fact that high temperatures are fatal to the pika does not necessarily prevent the occurrence of the species in regions where high day temperatures occur, and, in fact,

one subspecies, *Ochotona schistıceps goldmani*, occurs on the lava desert of Idaho. Here, however, the night temperatures are nearly always cool, and during the heat of the day the animals would be able to retire to cool caves under the rocks.

Museum of Zoology, University of Michigan,
Ann Arbor, Michigan.

THE EUROPEAN BISON IN SWEDEN

By Clyde Fisher

[*Plate 22*]

In the fall of 1923, there was in Skansen, the unique outdoor museum and zoological park in Stockholm, a herd of seven European bison, at that time the largest herd in the world. The total number of individuals then known to exist in the entire world was only fifty-six, the remnant after the killing during the world war, and most of these specimens were degenerate and in poor condition.

With the saving and restoring of the American bison in mind, the Swedes turned their attention to making an attempt to save their herd of European bison. About this time General Consul Axel Axelson Johnson offered to the Skansen management in Stockholm the use of a tract of one hundred acres, belonging to him, at Långsjö, Västmanland, to be used as a preserve for the collection of bison then at Skansen. The offer was accepted and a part of the herd, consisting of three head, was safely transported in crates by train and then by wagon from Stockholm to their destination, and set at large there. This was witnessed by natives from far and near and by several foreign notables, as well as Superintendent of Skansen, Mr. Behm, and General Consul Johnson. These three bison, one bull and two heifers, were born in captivity at Skansen, and were released at Långsjö on July 21, 1924.

The area devoted to the bison is very well adapted to its present use, consisting of meadows, forest and lake, with plenty of good grazing. Feeding-sheds for winter have been established. The whole tract is surrounded by a ten-pole stockade or fence.

I visited Skansen in mid-June, 1924, before any of the bison had been removed, and again the last of July after the first three had been taken

away. On the latter visit I noted a young calf and its mother which were later transported to Långsjö, bringing the total number in the preserve up to five.

It is hoped that under these favorable conditions the herd will increase and that the preservation of this fine animal will be assured.

Before writing this brief report, I inquired of Dr. Einar Lönnberg, who has charge of mammals in the Natural History Riksmuseum at Stockholm, concerning the present status of the European bison in Sweden and following is his reply, dated March 25, 1926:

"In reply to your question about the status of the European bison in this country, I have the pleasure of informing you that it now is ten in number, viz: five here in Stockholm at Skansen and five in semi-liberty in a large park in the Province of Västmanland. The biggest and oldest bull succumbed from great age some months ago [I believe they said in 1924 that he was fifteen years old.—C.F.] but it has received a successor and I hope the herd will continue to increase."

American Museum of Natural History,
New York City.

A Pair of European Bison in Semi-Liberty at Längsjö, Sweden
Photograph furnished by Swedish Traffic Association

UNIV. OF MICH.

SOME RODENTS FROM TRANSBAICALIA, EAST SIBERIA

By B. Vinogradov and S. Obolensky

We collected small mammals in Transbaicalia in the years 1924 and 1925 and succeeded in procuring there about eight hundred rodents belonging now to the Zoological Museum of the Russian Academy of Sciences. We were also able to study the type-specimens of Radde, Poliakov and Kastschenko from Transbaicalia in the collections of the above-named museum. We are here publishing preliminary remarks on some insufficiently known rodents from the Transbaical region and intend later to give a fuller review of all known species of that country.

Microtus michnoi Kastschenko

Total number of specimens examined, 43 from Duriony (type-locality) on the River Chikoi, 50 kilometers east of Troizkosavsk, and some specimens from the Lake Tarei-nor, South Transbaicalia.

M. michnoi is a large vole allied to *M. pelliceus* from Ussuri, as far as we could judge from examination of a large series of the last species from the type-locality. Both species have five tubercles on the hind foot, an additional sixth tubercle being rarely present; the enamel pattern of the first lower molar is also very similar in both species, with three sharp external salient angles and one mostly rounded or nearly smooth anterior one. The skull is rather smooth in both species, without any traces of median crest even in old individuals, and the braincase not so angular as in adult *M. oeconomus* or *M. ungurensis* (see below). A characteristic bow-shaped upper outline of the skull of *M. pelliceus* is rather well seen in many specimens of *M. michnoi*. Size of *M. michnoi* is about equal to *pelliceus*, only the hind foot and the ear in the first species seem to be a little shorter; condylobasal length and nasalia are somewhat longer in *M. pelliceus*.

M. michnoi, *M. pelliceus*, *M. calamorum*, and partly *M. fortis* form a rather characteristic East-Asiatic group, but we do not see sufficient reasons to separate them from the genus *Microtus*, as was done by S. I. Ognev who established for *M. pelliceus* and *M. calamorum* the new genus *Alexandromys* (Journ. Zool. Dep. of Friends of Nature in Moscow, 1914, vol. 11, no. 3, p. 109).

M. michnoi lives chiefly in valleys, on the shores of lakes, among bushes or reeds near water, that is, its habitat is similar to that of *Arvicola amphibius*.

M. maximovitzi Schrenk from Amur seems to be also allied to *M. michnoi* or *M. pelliceus*, but the unsatisfactory condition of Schrenk's single original specimen does not allow of a final conclusion. We examined also a specimen of vole determined by Schrenk as "*Arvicola terrestris*" from Amur and it also proved to be a representative of the *M. pelliceus* group.

Measurements. Extremes of ten adult specimens: head and body, 109–147 mm.; tail, 44–61; hind foot, 20–22.5; ear, 11–13; condylobasal length, 29.7–32.4; zygomatic breadth, 17–18; interorbital constriction, 4.0–4.2; occipital breadth, 13.1–13.8; occipital depth, 7.7–8.6; nasalia, 7.8–8.3; diastema, 9.3–10.6; maxillary tooth-row, 7–8.

Microtus ungurensis Kastschenko

Thirty specimens collected near Chita, a large series from the southeastern shore of Lake Baical (the mouth of Selenga River), and numerous specimens from the Zeya River, tributary of Amur (collections of the Zool. Mus. Russ. Acad. Sci.).

This insufficiently known vole was described by Kastschenko under the name *M. michnoi* var. *ungurensis* (Ann. Mus. Zool. Acad. Sci. Petersburg, 1913, vol. 17, p. 418); said author distinguishing it from *M. michnoi* by the dark color of the belly, hind feet and ears. The cranial characters seem not to have been studied by Kastschenko. The typelocality of this form is Makoveevo, about 50 kilometers southeast from Chita. Our series was collected near Chita and agrees in all characters with Kastschenko's specimens, but our examination of this animal enables us to consider it as a separate species. The skull of *M. ungurensis* is easily distinguished from that of *M. michnoi:* it is considerably more angular with sharply developed interorbital crest, is more flattened than in *M. michnoi*, the braincase is shorter and more angular, the coronoid suture is mostly squarish but not bow-shaped as in *M. michnoi*, or not forming one salient angle. The skull of quite adult specimens of *M. ungurensis* is a little smaller than in *M. michnoi;* interorbital constriction is less than 4 mm., whereas in *M. michnoi* it is 4 mm. or more. First lower molar has four external sharp salient angles (in *M. michnoi* the first angle is mostly rounded or nearly absent). The hind foot in *M. ungurensis* is rather short (extremes 17.5–19 mm.), but in *M. michnoi* it is 20 mm. or more (20–22 mm.).

We regard the said characters and many others sufficient for considering *M. ungurensis* and *M. michnoi* as independent species.

Measurements. Extremes of thirty adult specimens: head and body, 112–137 mm.; tail, 37–49; hind foot, 18–19; ear, 10–13: condylobasal length, 28.6–30.6; zygomatic breadth, 15.5–16.8; interorbital constriction, 3.4–3.8; occipital breadth, 12.6–13.1; occipital depth, 7.0–7.7; nasalia, 7.7–8.8; diastema, 9.0–9.7; maxillary tooth-row, 6.2–7.3.

Microtus mongolicus Radde

Sixty-one specimens collected near Chita, Borsa, and Soctui (two last localities about 75 kilometers northeast of the Lake Tarei-nor, type-locality), some specimens from Balsino, 100 kilometers south of Chita.

The systematic position of this vole, common in Transbaicalia, is very little known. We had the opportunity of examining carefully the unique original specimen of Radde, preserved very unsatisfactorily, and to compare it with our series of numerous specimens. As far as it was possible to judge from this examination, *M. mongolicus* is a little vole very similar to some small races of *Microtus arvalis;* the most obvious and constant character distinguishing this species from *M. arvalis* is the structure of the enamel pattern of the first lower molar. *M. mongolicus* has only three evident sharp salient angles on the external side of that tooth, the first angle (fourth from behind) being absent or representing only a blunt rounded projection, but in *M. arvalis* this tooth has always four sharp salient angles. The general color of *M. mongolicus* is similar to *M. arvalis obscurus* from Altai and West Siberia. However, the color of Radde's type-specimen is not so dark and has a considerable admixture of yellow, but it seems to us that nearly all Radde's specimens have lost their natural color and acquired an unnatural admixture of yellow (Radde's specimens of *Stenocranius raddei*, *Microtus brandti*, *Microtus oeconomus* and *Citellus dauricus*, as compared with fresh specimens collected in the same or nearest localities, also changed their color in the same way).

In connection with the examination of *M. mongolicus*, we examined also the original specimens of Kastschenko's "*Microtus poliakovi*" (= *M. gregalis* Radde and Poliakov, not Pallas) and came to the conclusion that both these species seem to be identical because all essential cranial and dental characters of *M. mongolicus* and *M. poliakovi* coincide, especially in the characteristic structure of the enamel pattern of the first lower molar as described above. The color of the original series of *M. polikovi* is variable (it was noticed also by Kastschenko); we consider these variations as seasonal and suppose a part of these speci-

mens to be in winter pelage while another part retained their summer coat. Unfortunately we had no fresh winter specimens of *M. mongolicus* and therefore could not examine critically these variations, but the mentioned supposition seems to us very probable.

M. mongolicus rarely lives in open dry steppes, but inhabits mostly more fertile valleys or meadows. We found it also in forest regions of Transbaicalia, especially in valleys covered with *Betula fruticosa*.

Measurements. Average and extremes of fifty specimens: Head and body, 96.4 mm. (75–113 mm.); tail, 28 (20–38); hind foot, 14.9 (13–17.4); ear, 9.5 (7–12). Average and extremes of twelve skulls: condylobasal length, 23.9 (23–26); zygomatic breadth, 13.5 (13.2–14.5); occipital breadth, 10.7 (10.3–11.8); occipital depth, 6.2 (6.0–6.7); interorbital constriction, 3.5 (3.2–3.7); nasalia, 6.2 (6–7); diastema, 7.6 (7.3–8.3); maxillary tooth-row, 5.6 (5.5–6.1).

Microtus (Stenocranius) gregalis raddei Poliakov

Total number of specimens collected, 128; a considerable number of these were caught in Borsa and Soctui about 75 kilometers northeast of Kulussutai on Lake Tarei-nor, that is, the type-locality of *M. raddei*. We found this vole near Chita, Verkhne-Udinsk and Troizkosavsk.

Our series is distinguished from Poliakov's original specimens (Radde's collection) by considerably more grayish color: the yellowish tint of Radde's specimens is not so intense in our series, but we are inclined to consider it only as a secondary modification of the natural color in Radde's specimens during the long series of years, as it can be observed in nearly all specimens in Radde's collection. The most yellow specimens of our recent collection approach "hair-brown" (17 ""i) of Ridgway; the grayest specimens of our collection are near "mouse-gray" (15 """); all intermediate tints are also observed in our series. We notice that the greater part of the old males have the grayest color while the greater part of the females have a considerable admixture of yellow.

We examined also some specimens of *M. raddei* collected near Urga, North Mongolia; these specimens are not essentially distinguishable from our Transbaicalian series. The Mongolian *Stenocranius* described by O. Thomas under the name *S. angustus* seems to us very similar to *S. raddei*, or identical with it, but unfortunately we had no specimen of *S. angustus* from its type-locality (Kalgan), and therefore could not study their systematic relations.

M. gregalis raddei inhabits in great numbers the dry Transbaicalian steppes. It is one of the commonest native voles and replaces there *M. gregalis slovzovi* which lives in South Siberian steppes from Ural Mountains to Lake Baical.

Rattus norvegicus caraco (Pallas)

Twenty-five specimens from Irkutsk, Alari (government of Irkutsk, district of Balagansk), Verkhne-Udinsk, Troizkosavsk, and Chita.

The brown rat from Transbaicalia was described by Pallas under the name "*Mus caraco*" and later the same animal was named by Kastschenko *Epimys norvegicus primarius*. Pallas described correctly some characters distinguishing the Transbaicalian rat from the typical form; besides Pallas, nobody has found an animal completely answering his description. It was possible to confirm in our material the shortness of the hind foot which does not exceed 35 mm. in Transbaicalian specimens (in the typical form it is more than 40 mm.), and the shortness of the skull (the greatest length of the skull of rats from Troizkosavsk district is less than 42 mm.; the average of ten rats from Petersburg is 44.9 mm.). But the narrowing of the skull mentioned by Pallas was not noticeable in our specimens. The Transbaicalian rats are colored like European specimens; three specimens from the River Chikoi near Duriony (Troizkosavsk district) have actually very dark backs; one of these specimens has evident traces of winter pelage contrasting sharply with darker summer coat. This peculiarity enables us to suppose that the brown rat living under natural conditions has seasonal dimorphism, and that like many other mammals its summer fur is darker and its winter is lighter. In the length of tail and number of scale-rings *R. n. caraco* is not distinguishable from the typical form: the tail is about three-fourths of head and body, and the number of rings is 160 to 190 (according to Pallas there are 150 rings). The number of lumbar vertebrae in two of our spirit specimens is six (Kastschenko found five). Mammae 10 (Pallas found 8; European brown rat has usually 12, but occasionally also 10).

As was shown above, the Transbaicalian rat may be considered a subspecies of *Rattus norvegicus*, but the description of it by Pallas and Kastschenko must be corrected in some characters.

R. n. caraco lives not only in buildings, but very often also under natural conditions preferring damp places near water in thickets of *Salix;* its habitat is very similar to that of the water-vole (*Arvicola amphibius*), which seems to be absent in Transbaicalia.

Mus (Nemomys) major Radde

We examined a large series of harvest mice from different localities in Transbaicalia and other parts of eastern Siberia and compared the specimens with the original series of Radde. Most of our specimens have a little darker backs than those in Radde's series, but some of ours from the western shore of Baical and also some from Transbaicalia are not essentially distinguishable from Radde's specimens.

We consider this mouse as an independent species of the harvest mouse group. Some peculiarities of these mice distinguish them from the groups of *Mus flavicollis* and *Mus sylvaticus* and ally them to the *M. agrarius* group, as for example the number of mammae (8), the presence of a supraorbital crest on the skull, the arch-shaped fronto-parietal suture, the relatively broad interorbital constriction, and the bluntness of the external ends of interparietal bone. The *M. sylvaticus* and *M. flavicollis* group received from Ognev (1923) the generic name *Sylvaemus*, but the characters of East Siberian mice do not allow of giving them this name. One can use for them the name *Nemomys* given by O. Thomas (1924) to certain mice of these groups separated by him from *Apodemus*. We are inclined, however, to consider *Apodemus*, *Sylvaemus*, and *Nemomys* only as subgenera of the single genus *Mus*.

Mus major Radde is closely allied to *M. chevrieri* Milne-Edw. from central Asia; we had the opportunity to examine some specimens of this mouse collected in Kansu and found them very like our Transbaicalian specimens in color. But the color of our specimens of *M. raddei* is not identical with that figured in the colored plate of Milne-Edwards' work; our specimens are duller on the back, a yellowish brown with reddish rufous tint and with considerable admixture of black hairs.

Harvest mice from Altai apparently belong to the same group as far as we could judge from examination of specimens collected by us in 1923 at Tigerek and some specimens from Uimon (Coll. of Zool. Mus. Russ. Acad. Sci.). These mice were probably described by Hollister (1913) under the name *Apodemus nigritalus;* however, a representative of true *M. sylvaticus* (*M. s. tscherga* Kastsch.) is also present in the Altai Mountains.

Measurements. Average of twelve specimens from Transbaicalia: head and body, 103.3 mm.; tail, 93.9; hind foot, 22.4. Average of fourteen adult skulls: greatest length, 27.5; condylar length, 23.7;

zygomatic breadth, 14; interorbital constriction, 4.4; nasalia, 11.1; diastema, 8.1; upper tooth-row, 4, 3.

Gerbillus unguiculatus Milne-Edw.

We examined a large series of gerbils from Troizkosavsk district, southwest Transbaicalia, and found the specimens very similar to *G. unguiculatus* M.-Edw. from North Mongolia. However, Transbaicalian gerbils are somewhat distinguishable from the typical *G. unguiculatus* and also from the nearly allied species *G. kozlovi*. The belly in Transbaicalian gerbils has a yellowish tint, but in *G. unguiculatus* it is yellowish pale gray, and in *G. kozlovi* pure white, occasionally with a faint yellowish tint. The skulls of our specimens are quite identical with those of the typical *G. unguiculatus*.

Zoological Museum, Russian Academy of Science, Petrograd.

A TRUE MARTEN FROM THE MADISON VALLEY (MIOCENE) OF MONTANA

By James W. Gidley

INTRODUCTION

A small lot of fossil vertebrate remains was recently sent to the National Museum for determination by Prof. C. A. Kinsey. These specimens were collected by him from the Madison Valley (Upper Miocene) deposits near Belgrade, Montana. In this lot is a small jaw representing an extinct species of musteline which seems, without much question, to belong to the living genus *Martes*. This specimen is the basis of the present communication.

As Matthew has formerly noted[1] the number and variety of mustelids of the Miocene and Pliocene is very large, yet they appear for the most part to be not closely related to modern types of this group. Some of these have been referred to existing genera, but as also noted by Matthew, this usually has been done on negative evidence because of the absence of distinctive generic characters in the material studied. The specimen here described, therefore, is the more interesting because its generic

[1] Bull. Amer. Mus. Nat. Hist., vol. 50, 1924, p. 128.

reference can be based on positive dental characters which seem to prove a real relationship to the modern genus *Martes*.

Martes kinseyi[2] new species

Type. Greater part of a right lower jaw carrying most of the dentition. (P_2, p_3 and p_4 are broken, and p_1 and c are represented by their alveoli. Catalogue No. 11,644 U. S. National Museum Coll.)

Type locality and horizon. Near Belgrade, Montana, Miocene deposits. Collected by C. A. Kinsey of Belgrade, Montana.

Diagnosis. Size slightly larger than *M. americana*. Lower jaw relatively deep posteriorly, its depth at middle of carnassial slightly exceeding greatest length of this tooth; premolars relatively long, length of p_4 equaling two-thirds the length of the carnassial; p_3 and p_4 with posterior cingula well developed, forming relatively wide but very short basin heels; lower carnassial long and

FIG. 1. MARTES KINSEYI GIDLEY, TYPE (CAT. NO. 11,644, U. S. N. M. COLL.)
Portion of a left lower jaw; two views; both natural size

straight but with relatively narrow heel, and well developed metaconid; m_2 relatively long, being about two-fifths the length of the carnassial, and wide anteriorly with very small narrow heel.

Measurements. Length of dental series p_1 to m_2 both inclusive 31.3 mm.; length of p_2 (estimated) 4.5 mm.; length of p_3 5.3 mm., width of heel 2.5 mm.; length of p_4 6.7 mm., width of heel 3 mm.; length of carnassial 9.7 mm., greatest width 4 mm.; length of m_2 4.2 mm., greatest width 3.7 mm., width of heel 2.5 to 1.8 mm.; depth of lower jaw below middle of carnassial 10.8 mm., depth below middle of p_3 9.5 mm.; greatest thickness of jaw below carnassial 5.6 mm.

The upper dentition is not known, but the relatively close correspondence in form and size of m_2 and the lower carnassial with those of the living species of the genus indicate that the upper cheek teeth would show the same characteristic modifications found in *Martes*.

COMPARISON WITH LIVING SPECIES

The species here described is distinctly separated by its combination of characters from all the living species of *Martes*, but its ensemble of

[2] I take pleasure in naming this species in honor of the discoverer and donor of the specimen on which it is based.

modification as shown in the type specimen definitely indicates its proper reference to this genus. In fact it differs less from the type species of *Martes* than do some of the other living forms now assigned to it. Judged by the somewhat greater depth of jaw below the carnassial, the less reduced condition of m_2, and the slightly larger premolars, the fossil species may be considered somewhat more primitive; but in other respects it is entirely modern in development. Its major specific distinctions are as follows:

Martes kinseyi differs from all the Old World martens examined in that the carnassial is straighter and relatively narrower. In this respect and certain other features it more nearly resembles *M. americana*. As in this species the premolars are somewhat crowded so that p_2 is turned outward anteriorly and slightly overlaps p_1, which, in turn, is placed close against the canine. The latter species differs from *M. kinseyi*, however, in that the heels of the premolars in *M. americana* are very narrow with the posterior cingulum but little developed, the heel of the carnassial is relatively broad, m_2 is more reduced and the jaw is relatively very shallow.

Except for its much smaller size, the fossil species perhaps most resembles *M. pennanti* among the living forms. In this species the jaw is deeper, in some specimens nearly but not quite equalling in relative depth that of the fossil jaw: the posterior cingulum of p_4 is well developed and the heel of this tooth is wide. The heel of p_3 is narrow and almost without cingulum. M_2 is less reduced than in the other living species but is slightly more reduced than in the *M. kinseyi*. The composition of m_2 in these two species, however, is quite different. The triturating surface of this tooth in all species of *Martes* presents two depressed areas antero-posteriorly placed and divided by a low transverse ridge. These are the basins of the trigonid and talonid, respectively. In *M. pennanti* and most of the living species these two basins are subequal in size. In *M. kinseyi* the heel basin is much reduced both in length and width, and occupies less than one-fourth the area of the anterior one. This tooth in two of the Old World species, *M. brachyurus* (Japan) and *M. foina* (Kashmir), approach that of the Montana fossil species in the reduction of this posterior basin.

COMPARISON OF TOOTH CHARACTERS IN MARTES AND MUSTELA

Species of *Martes* have sometimes been mistakenly referred to the genus *Mustela*. It therefore may be noted in this connection that

species of these genera can be readily distinguished on differences in tooth-cusp characters observed especially in the lower carnassial, lower m_2 and upper m_1. These teeth in the two genera are correspondingly similar in general appearance except that in *Mustela* m^1 and m_2 are usually somewhat more reduced. In *Martes*, however, the metaconid is present in the lower carnassial although not always clearly distinguished, and the talonid is of the basin type with the hypoconid set near its outer margin. M_2, although much reduced, still retains two shallow basins, one anterior (trigonid) the other posterior (talonid). These are separated by a very low transverse ridge, joining the but slightly elevated hypoconid and metaconid. In *Martes* also the single upper molar, m^1, is shortened in its outer portion, but still retains a broad protocone-hypocone shelf adapted for crushing. The metacone is much reduced and is rather closely appressed to the paracone. The protocone is but little elevated and forms a low ridge which begins about the middle of the shelf near the inner cingulum and curves forward and outward to meet the anterior border of the tooth crown near its middle point.

In *Mustela* the lower carnassial lacks the metaconid, and the talonid is sub-trenchant, the hypoconid being medially placed forming a longitudinal ridge. M_2 in this genus is divided into two laterally-sloping areas by a longitudinal median ridge, making the crown trenchant as compared with the flat topped crown observed in *Martes*. The upper molar, m^1, in *Mustela* is clearly distinguished from that of *Martes* by a modification of the protocone which appears as a low, cone-shaped cusp near the middle of the protocone-hypocone shelf.

U. S. National Museum, Washington, D. C.

GENERAL NOTES

PIZONYX VIVESI ON ISLA PARTIDA, GULF OF CALIFORNIA

One of the fruits of the expedition despatched by the California Academy of Sciences to the Gulf of California in 1921, was a small series of bats preserved in alcohol. This series included seven specimens of *Pizonyx vivesi*, taken on April 21, 1921, at Isla Partida, about twelve miles north of the islet of Cardonal which is the type locality of the species.

The specimens were secured by Joseph R. Slevin, assistant curator of the Department of Herpetology, who was in command of the expedition. These bats were found occupying interstices in the rock slide where *Oceanodroma melania* was breeding.

In view of the paucity of literature relating to *Pizonyx vivesi*, it has been considered desirable to place the measurements of these specimens on record.

Measurements of skins

	TOTAL LENGTH	EAR FROM CROWN	TRAGUS	FOREARM	THUMB	TIBIA	HIND FOOT	TAIL
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Males	141	14.75	9.00	58.5	10.0	23.25	24.00	63.50
	138	14.00	9.50	60.0	10.0	21.00	24.10	59.90
	135	13.50	9.10	60.5	10.0	23.00	23.00	50.00
	138	14.75	9.75	58.0	9.9	22.75	23.25	63.00
Females	145	14.90	9.90	60.1	10.1	23.25	23.00	64.75
	139	14.50	9.00	60.0	10.5	23.00	23.05	59.90
	138	14.50	10.00	60.0	10.0	23.00	22.40	61.00

Measurements of skulls

	BASAL LENGTH	PALATAL LENGTH	HEIGHT OF BRAIN-CASE	WIDTH OF BRAIN-CASE	INTER-ORBITAL WIDTH	ZYGO-MATIC BREADTH	LENGTH OF MANDI-BLE
	mm.	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*	*mm.*
Males	18.3	11.7	7.3	10.5	5.6	....	17.2
	18.6	12.0	7.4	10.5	5.5	14.2	17.3
	19.2	12.4	7.7	10.2	5.5	....	17.4
	19.1	12.1	7.3	10.5	5.4	14.2	17.2
Females	19.1	12.0	7.3	10.7	5.5	....	17.2
	18.5	12.2	7.1	10.6	5.3	....	17.1
	18.2	11.5	7.1	10.3	5.6	....	16.9

—M. E. McLellan, *California Academy of Sciences, San Francisco, California.*

NOTES ON THE YOUNG OF THE RED BAT (NYCTERIS BOREALIS BOREALIS)

July 4, 1921, a female red bat with three clinging young was found in Ann Arbor, Michigan. Another female red bat, also with three clinging young, was found in the same city on July 11, 1926, but in this latter case the young were much smaller

and with the eyes barely open. The most interesting thing about the young in both these cases was the pronounced difference in color between the males and the females, the pelage of the young males being dark red, while that of the young females was gray, with just a trace of red. As reported by Mrs. Grinnell, Hollister and Miller have noted the difference in the coloration between males and females which occurs in the eastern red bat, but in the young bats the difference in color between the sexes is much more pronounced than in the adults.

The female red bat found in 1926, above mentioned, was able to spring into flight from a floor, and was able also to fly directly upward out of a small box about eight inches deep. In these flights the clinging young had been removed, and it is possible that the female might have been unable to take flight from a flat surface if encumbered by the young. When trying to escape from her cage the female often forced the young to leave her, pushing them off with her wings and mouth, possibly even biting them gently in order to make them let go their hold of her body and fur. The young bats then hung themselves up in a group wherever they happened to be in the cage. I am not sure that the female would have returned to these young, but perhaps this whole proceeding was due to the abnormal cage situation.—L. R. Dice, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

AN UNUSUAL HABIT OF THE MINK

Some observations of an unusual habit of the mink seen some years ago, have been reported to me by the men who saw the performance. Fred Knowles a trapper, has seen it two or more times, and Herbert Potter an old and inveterate fisherman, has seen it once, and in all cases on the West Canada Creek which forms the western boundary of this village. They have seen what appeared to be a knot floating down stream but in reality a mink curled up and apparently asleep. Motion on the part of the men always awoke the animal and caused it to dive and sometimes appear on the bank some distance up stream. Knowles claims that it was always in the fall of the year that he saw this and on bright sunny days.

This may be a common habit of the mink but I failed to find any reference to it in any of the works that I have read.—Charles A. Gianini, *Poland, New York.*

A GRAY SQUIRREL CARRIES ITS YOUNG

A throng of about two hundred and fifty people in the New York Zoological Park on the afternoon of October 3, 1926, attracted my attention to an adult gray squirrel (*Sciurus carolinensis*) walking along a half-inch cable between two trees. This taut cable, about seventy-five feet long, coursed at an angle of approximately thirty degrees from one large oak to another and served as a brace for one of these trees.

On the lower end of this cable, some fifteen feet above the ground, sat a very young gray squirrel, an individual perhaps one-third grown. The adult, presumably the mother, was near the other end. This adult walked out about half way along the cable, only to turn around and go back. Again it did this. The third time, the adult came up to within a few inches of the young one, turned and again walked back up the cable for several feet. To all appearances the adult was trying to coax the young one to follow. Returning once more to the young-

ster the parent stepped over the smaller squirrel and tried to push it out along the cable. There was no visible inclination on the part of the baby to yield and the attempt failed.

The next attempt on the older squirrel's part was to seize the young by the skin of the chest. After pushing the little one over so that it was suspended in a sloth-like position from the cable, it did succeed in getting a good hold with its incisors. On being lifted up from its position, the baby curled itself around the head of the parent in the same position shown in the photographs taken by Dr. Lillian D. Powers which were used to illustrate the paper by Herbert Lang.[1]

The parent proceeded to carry the young across the wire rope, not however without faltering and losing its balance to such an extent that the assembled crowd of *Homo sapiens* below gasped in chorus. The end of the cable was reached and the young carried up a few feet to a large outside nest of dry leaves. Quickly the adult came back over the aerial runway with tail gracefully arched and responding to each new demand of position.

Five feet higher in the tree than the lower end of the cable was the small entrance to a natural cavity in which was the squirrel's other nest. Another young squirrel had occasionally shown its head at this entrance. The adult went directly to the hole and thrusting both head and shoulders in tried to seize and pull out the obstinate baby, but though working at the task continuously for fifteen minutes the end was not accomplished. Twice the adult went in the cavity completely and tried to push out the young one. The second trial was rewarded with success; but, once out of the hole with its burden, the adult strangely enough allowed the young its freedom. An attempt was then made to get the same hold on this small squirrel as on the first baby, but back into the nest the young one scampered and the adult after a few more attempts to pull it out descended to a lower limb to rest.

From the remarks made by individuals among the watchers I gathered that several young had previously been transferred from the hollow tree to the outside nest, but just how many I was unable to determine. It was not possible to remain longer to see whether the last youngster was safely transferred.—ROBERT T. HATT, *New York University, University Heights, New York City.*

NOTES ON BEAVER ANATOMY

The following notes on beaver anatomy were made by the writer in March, 1926, upon animals trapped under permit in the vicinity of Shields River, Montana.

Specimen number 2

Female, good physical condition, three or four years old; three young in uterus, about one-half developed; had been dead about fifty hours when examined.

Weight without hide and one front foot	40 pounds 2 ounces
Weight without hide, pluck and intestines	28 pounds
Weight of brain	1.25 ounces

[1] Lang, Herbert, How squirrels and other rodents carry their young. Jour. Mammalogy, vol. 6, no. 1, pp. 18–24, February, 1925.

Weight of full stomach	6.5 ounces
Weight of lungs	2.6 ounces
Weight of heart	2.1 ounces
Weight of placenta, each	0.5 ounce
Weight of fetus, each	0.5 ounce
Weight of entire sac, each	4.2 ounces
Weight of kidneys, both	4.4 ounces
Weight of liver without gall sac	19.0 ounces
Length of large intestine	7 feet
Length of small intestine	19 feet 2 inches

Specimen number 3

Female, barren, two years old, diseased, poor physical condition; had been dead twenty-four hours when examined.

Weight with hide	25.5 pounds
Weight of heart and lungs	6.5 ounces
Weight of kidneys, both	3.7 ounces
Weight of liver and full gall sac	1.0 pound
Length of large intestine	7 feet
Length of small intestine	22 feet 10 inches

—W. M. Rush, *U. S. Forest Service, Livingston, Montana.*

GOLDEN MICE IN UPPER SOUTH CAROLINA

Some years ago it was my pleasure to be able to put in a short while studying the golden mice in a small wood near Troy, South Carolina, a little village about forty miles north of Augusta, Georgia. The variety in this vicinity is *Peromyscus nuttalli aureolus*. I found these mice nesting among the branches after the manner of birds, and also in one case in the hollow of a small tree. The open air nests were very much like those of *Peromyscus leucopus* as described by Bachman,—a mass of leaves and trash, longer than broad, situated from six to ten feet above ground, and apt to be taken for some deserted bird's nest. The interior was lined with fiber taken from the inside of dead bark, and the only indication of a door was an almost indiscernible place at one side where the material clung together a little less tenaciously than elsewhere.

Passing through a small body of wood with a great deal of low undergrowth, I one day came on a nest of this mouse about eight feet from the ground in a thorn-bush and very near the narrow wagon-road. I bent the bush over in order to get at the nest, when a mouse sprang from it, struck in a tiny pine bush at my knee, and cowered there as if fearing to move lest I should see it. Taking off my hat, I so folded it that it left a tempting hole to a frightened mouse, and the little creature crept inside. Cutting off the top of the bush that held the nest, I bore my trophies home, where I caged the little animal in a tin can with holes in the lid for ventilation. A small paste-board box and some trash were placed inside to provide the means for nest building, and a supply of acorns and other food was given it. It soon took possession of the paste-board box, but would occasionally climb up on top of it, and reaching up try to cut its way to freedom through the

air-holes in the lid of its tin prison. However, after several days, it became very docile, and when taken out, sat on my hand and ate in a very domestic manner. It had a very strong grasp, reminding me of the climbing abilities of one of the quadrumana, and the same day when I watered it through a fountain-pen filler, or medicine-dropper, it caught hold of the glass tube and climbed it without apparent difficulty, a fact that was all the more surprising when I found later that the little fellow was suffering with one broken leg! This injury evidently affected the health of the mouse, and it became sick. I changed its quarters to a better bed in a cigar box where one morning I found it dead.

As previously noted, it was very difficult to tell just what part of the nest the inmate would pop out of, owing to the difficulty of locating the door. It apparently imitated a hard-working old bachelor when it retired, and wattled itself in among the bed clothes without spreading them properly. Another of these animals that I encountered in the same wood stuck its head from its nest, also perched among the branches of a bush, decided that that way of escape was unsafe, pushed out at another side, and ignoring the hat with the "creeping-into" hole that I again provided, attempted to make its get-away by climbing. It reached the top of a small oak sapling and crouched very still, trying to escape observation. When I bent the tree over, and thwarted it in its efforts to escape among the overhead branches, it took to the ground and escaped, but evidently it would have preferred escape by the arboreal route.

On the last day of February, soon after the above described incidents, I was fortunate enough to procure from a small hollow tree a nest containing a pair of these mice. I placed these in a box covered with a pane of glass, and provided food and water. So tame did they become that they would climb about my hands and body in a very docile manner, and just as remarkable was the fact that a young lady in the boarding house, who had seen the advent of the rodents with the proverbial feminine horror, fell in love with the little fellows and would permit them to crawl about her arms and hands, while I feared they might run up her sleeve and be destroyed during a fit of returning fright. Bothered with a small mite-like parasite, the mice frequently scratched with the hind feet after the manner of a poodle, and once in a while would peer under their arm-pits as if to get their tormentors more effectively. When they were busy at night, a sudden light from a match did not seem to frighten them, the only effect being their "freezing" from the apparent blindness. These two finally forced the pane of glass on their box and made their escape.

My observations, incidentally, were made at no great distance from the site of the old home of John Barratt, who seems to have been the only aid John Bachman had in the upper part of the state in which he lived, and Bachman praises his ability warmly. Unfortunately, at Barratt's death his mantle fell on no one; his museum was neglected, his correspondence destroyed, and so far as I can determine he was not familiar with this form which Bachman described. For two generations after his death no serious nature work seems to have been attempted by permanent residents. An allegedly cultured, newly-rich mill-president smiled superciliously at a college professor, who thoughtfully provided for the remains of Barratt's collection, now sadly deteriorated. Like the proverbial man who could not appreciate the Golden Rule for the rule of gold, he could not appreciate golden mice, but might have worked up a lively interest in

mice of gold such as the Philistines are described as making in the sixth chapter of First Samuel. If Barratt's museum contained any of these mice they have been hopelessly lost, and after his day mammalogy had little resident attention devoted to it in upper South Carolina. But a new day has arisen. In prosecuting my work here I now have the aid and encouragement of the college professor and student, the high school teacher and student, and a number of enthusiastic amateur naturalists. To such in the lower Piedmont region of the Carolinas and Georgia I would commend *P. nuttalli aureolus* as a highly interesting little animal for further study.—ANDREW L. PICKENS, *Greenville, South Carolina.*

DICHROMATISM IN A LITTER OF RED-BACKED MICE

It is well known that the red-backed mouse (*Evotomys*) in New Brunswick occasionally shows a melanistic phase in which the red coloring of the back is replaced by blackish. This tendency so far increases in the southern Labrador form (*Evotomys proteus*) that dark individuals may outnumber the red ones, as at Hamilton Inlet, with all intergradations between the two extremes. In this connection it is therefore interesting to record two very young specimens presented to the Museum of Comparative Zoölogy by Dr. Charles W. Townsend. These were from a litter found on Mount Albert, Gaspé County, Quebec, July 10, 1922. One of the young is in the typical red phase, the other has the red entirely replaced by black. It is unfortunate that no record could be secured as to the number and color of the other young. Specimens from this locality are referred by Goodwin (Journ. Mamm., vol. 5, p. 254, 1924) to typical *gapperi* and their variation is noted. Probably the Labrador form, *proteus*, should be regarded as only subspecifically distinct.—GLOVER M. ALLEN, *Museum of Comparative Zoölogy, Cambridge, Massachusetts.*

PITYMYS PINETORUM SCALOPSOIDES IN WISCONSIN

While making a collection of small mammals in Worden Township, Clark County, Wisconsin, in 1925 I secured a specimen of *Pitymys pinetorum scalopsoides*. As far as I can ascertain this is the first record for this species in Wisconsin. This mouse was caught in a pit, which I had dug for the purpose of catching some jumping mice. The pit was located in a forest of hard maple, elm, yellow birch, and basswood with an undergrowth of young trees. The forest floor was covered with a dense growth of ferns. The soil consisted of a heavy glacial clay covered with about eight inches of black loam and humus.

This specimen is now No. 25733, Field Museum of Natural History, and was caught on August 25, 1925. It is an adult male, and measures as follows: total length, 126 mm.; tail, 24 mm.; hind foot, 18 mm.

Charles B. Cory in speaking of the mole mouse (*Pitymys pinetorum scalopsoides*) in his "Mammals of Illinois and Wisconsin" (p. 225), says: "The exact range of the Mole Mouse in Illinois is uncertain. Bailey records it from West Northfield, Cook Co., and from Warsaw, Hancock Co. Kennicott states it was common in northern Illinois and southern Wisconsin, but the latter statement at least is questionable, as so far as I am aware there is no actual record of its having been taken in Wisconsin." This new record indicates that *Pitymys pinetorum scalopsoides* ranges well into Wisconsin.—F. J. W. SCHMIDT, *Stanley, Wisconsin.*

RATS ARE GOOD SWIMMERS

While fumigating rat (*Rattus norvegicus*) burrows with calcium-cyanide dust along the banks of a small duck pond at a private game park near Washington, D. C., I saw an old female rat, driven from its hole, leap from the bank a distance of about two feet into the water, dive down, swim under water, and come up again about forty feet away. The animal immediately dove again, dodging some stones thrown in its direction, and this time swam under water about twice the former distance and came to the surface near a bank. The rat died soon after reaching the shore, as it had inhaled calcium-cyanide dust before entering the water.

In an article in the SATURDAY EVENING POST for August 1, 1925, James H. Collins says, "The brown rat entered Europe by swimming the river Volga in 1727 and reached England the following year, the same year as the Hanoveran monarchy, giving these rats the name of Hanoveran rats."—F. N. JARVIS, *U. S. Biological Survey, Washington, D. C.*

THE WHITE-TAILED JACK RABBIT EATS DANDELION STALKS

Out here in the west, the jack rabbit is so hunted and harassed as a pest of the farm that it is well to take into account all its activities. A day or two ago, I found one of these jack rabbits eating the stems of the common eastern dandelion which has been introduced here accidentally, and is now well established. So far as I could see the jack rabbit did not take the stems that had flowers on them but selected those that bore a fluffy seed head; but the actual seed heads it bit off and discarded. As it finished one stem, it would cut the next one at the base and then take the stem in its mouth endways. As the animal ate, the stem rapidly shortened and disappeared down its throat. The whole process reminded me of a child with a stick of lemon candy. I timed the rabbit for ten minutes and during that time it consumed eighty stems, usually one at a time, but once I saw it eat four stems at once. In addition to the ten minutes when I counted the stems, the rabbit continued eating for twenty minutes before a passing ranger disturbed him.—M. P. SKINNER, *Yellowstone Park, Wyoming.*

THE SPEED OF PRONG-HORN ANTELOPES

During the month of February, 1918, while working in the vicinity of Rincon, New Mexico, with Fred E. Keating, at present located with the Bureau of Plant Industry, I had an opportunity to observe the speed of prong-horn antelopes.

I was driving a Ford car on a straight road when I observed four antelopes, two does and two bucks, running parallel with the car, approximately 100 yards to my left and possibly 75 yards ahead of me. The smaller buck was at least one year old, and the other one appeared to be much larger and older. I was traveling 28 miles an hour when I first observed them and soon realized that they were gaining but little over the car. I maintained this speed for 7 miles, occasionally discharging a .32 calibre revolver into the air in order to keep them at maximum speed. They crossed the road ahead of me three times during that run, the two does and younger buck remaining constantly ahead of the older animal. During the entire run they were at no time farther than 200 yards from the road.

When the old buck crossed the road for the third time, he was not more than 15 feet ahead of me and approximately 300 yards behind the other animals. He was plainly fatigued. Every muscle in his body was being worked for speed. His head was rocking far up and down with every jump, and his tongue was extended from his open mouth. With admiration we stopped to watch the old fellow disappear into an arroyo as his companions had done before him. I believe the faster animals traveled the 7 miles at a rate of about 30 miles an hour, while the old buck's best effort appeared not to exceed 29 miles.—CARLYLE CARR, *San Leandro, California.*

SOME OF THE SMALLER MAMMALS OF MOUNT TIMPANOGOS, UTAH

While conducting the zoological work at the Brigham Young University Alpine Summer Session last year (1926), I had an opportunity to collect some of the small mammals of the Mount Timpanogos region, Utah. The university summer campus is at Aspen Grove on the north slope of this mountain at an elevation of 6,800 feet. The Canadian and Hudsonian zones above the camp are wooded with a varying mixture of *Picea pungens, P. engelmanni, Pseudotsuga mucronata, Abies concolor, A. lasiocarpa, Pinus flexilis, and Populus tremuloides.* Some of the sub-alpine slopes are snow-clad all year, and water from the melting snow feeds several small lakes. Mount Timpanogos has an elevation of 11,957 feet and is the highest mountain in the Wasatch range.

The following list consists of only those species that have been studied from skins, with the exception of the badger, which was not collected but carefully observed in the field.

1. **Myotis californicus californicus.** Little California bat.—Three specimens were collected in the dining-hall of the camp on August 14, 1926. At twilight many bats could be seen flying about the campus. There may have been other species as some of them seemed to be larger than this species.

2. **Mustela arizonensis.** Weasel. One specimen was collected on August 2, 1926. This little carnivore is rarely met with in this region.

3. **Spilogale gracilis saxatilis.** Skunk. On August 13, one of these odoriferous animals took up quarters under one of the girl's dormitories after being chased by a dog. The camp was greatly relieved when it was shot and disposed of.

4. **Taxidea taxus taxus.** Badger. This species was observed seven different times from July 20 to August 20 in the forest of the Canadian zone. At two different times individuals were seen digging along the roadside near the camp.

5. **Marmota flaviventris nosophora.** Woodchuck. Two specimens were trapped in a rock slide at an elevation of 9,900 feet. These animals are rather common over most parts of the mountain at this elevation. They are easily trapped as two were taken in ten minutes after the traps were set.

6. **Citellus elegans.** Mountain ground-squirrel. Ground squirrels of this species were abundant and so tame that they would come around camp and climb upon the out-of-door laboratory tables. Careful observation showed that by August 8 about 90 per cent of the squirrels had gone into aestivation. Those remaining out were young ones. I left the camp on August 20, and did not have a chance to observe these non-comformists again until October 10, on which date

it was sunny and warm and nine squirrels were counted on the dry hillside near camp.

7. **Eutamias minimus consobrinus.** Wasatch chipmunk. This interesting little chipmunk was very common. It was observed gathering the berries of *Amelanchier oreophila*, *Symphoricarpos vaccinioides*, and *Prunus melanocarpa*. Six skins were collected.

8. **Sciurus hudsonicus ventorum.** Pine squirrel. The two specimens collected in this region do not agree in color and size with a specimen of this form which I collected in Logan Canyon, June, 1926. More skins should be collected throughout the region, and they may prove to be those of *Sciurus fremonti fremonti*, now known in Utah only from the Uinta Mountains.

9. **Glaucomys sabrinus bangsi.** Flying squirrel. The one mammal in the collection that is of greatest interest to the writer is *Glaucomys sabrinus bangsi*, not before definitely recorded for Utah. Howell (Revision of the American Flying Squirrels, North Amer. Fauna, no. 44, pp. 38–40, 1918) does not list this subspecies as found in Utah, but says, "southern limits unknown." I am informed by reliable individuals that flying squirrels have been taken in the following places in the Wasatch Mountains: Hobble Creek (east of Springville), Rock Creek Canyon, and Provo River (above Vivian Park).

This attractive little creature seems to be common, as nests were found and many animals observed. Several times during the day three and four individuals could be observed both in or out of their nests, which had been built in *Picea pungens*.

These little night prowlers are fond of cultivated cherries and would come into the tents for them. Some of these squirrels chose as their midnight sport that of "shooting the shoot" by sliding down the tents. Six skins are in the collection.

10. **Peromyscus maniculatus rufinus.** Tawny deer-mouse. This mouse is common in many parts of the Wasatch at this altitude. Five skins are in the collection.

11. **Neotoma cinerea cinerea.** Wood rat. This species was common after about August 5. It is true to its name "pack-rat," as they are guilty of adding to their home comfort at the expense of the students in camp. Four skins are in the collection.

12. **Erethizon epixanthum.** Porcupine. From August 5 to August 20 many porcupines were seen, and four were killed. No attempt was made to skin them. All were large and very fat. Many of the coniferous trees have been partly barked by this animal.

13. **Ochotona princeps uinta.** Uinta pika or cony. The squeaky notes of this little rabbit-like creature may be heard coming from the rock slides at an elevation of 10,000 to 11,000 feet. The pikas are well protected in the bluish limestone and pinkish quartzite rock-piles, which makes it difficult to find and observe them. One specimen was taken on August 12 by one of my students, James Kartchner.—Vasco M. Tanner, *Brigham Young University, Provo, Utah.*

RECENT LITERATURE

Burrell, Harry. THE PLATYPUS: ITS DISCOVERY, ZOOLOGICAL POSITION, FORM AND CHARACTERISTICS, HABITS, LIFE HISTORY, ETC. Sydney: Angus and Robertson, Ltd. 8vo, 227 pp., 35 pls., 1 colored. Cloth, 25s. April, 1927.

Those who have been familiar with Mr. Burrell's studies upon the platypus have long looked forward to the publication of this book. Nobody, however, could have anticipated a more delightfully complete, accurate, and fascinating account, even of this most interesting animal, than the author has presented. Burrell has devoted nearly twenty years to the investigation of this mystery mammal; he has lived with it both in field and laboratory; he is the authority on *Ornithorhynchus*. Yet all this not without difficulties, for our author states in his preface, "the limitations under which the work has had to be carried on, and the impossibility of obtaining official sanction to work as a private collector, have prevented me from exploring certain branches of the subject and have brought my field-work practically to a standstill." One can but wonder what might have been the accomplishments of Burrell had he been unhampered by government restrictions.

Although our author does not go into all the details of taxonomy and anatomy, the first half of the book devotes no little attention to these phases of the study, and presents an account of the history of the animal since its discovery in November, 1797, together with discussions of the various controversies which arose in regard to it and its habits. The later chapters are devoted almost entirely to habits and related topics, and include detailed accounts of the nesting-burrow, distribution and haunts, breeding, life-history, preservation and economics, and the platypus in captivity. A fairly complete bibliography follows.

The platypus is of more than ordinary interest. It represents a type important both from the biological and the evolutionary standpoint. Burrell's work should therefore find wide use in libraries, both public and private. The book is attractively bound in dark red cloth, the paper is of excellent quality, and the illustrations unusually clear. Copies may be obtained from The Australian Book Company, 16 Farringdon Avenue, London, E. C. 4, as well as from the publishers. —HARTLEY H. T. JACKSON.

Warren, Edward R. THE BEAVER: ITS WORK AND ITS WAYS. Monographs of the American Society of Mammalogists, no. 2. Baltimore: The Williams & Wilkins Company. 12mo, xx + 177 pp., 47 halftone plates, and 7 line drawings, including one map. Cloth, $3.00. April, 1927.

Probably more books have been published on the beaver than any other North American mammal, but it is a safe assumption that we do not yet know all that is worth knowing about these valuable fur-bearing rodents. From the early days of wild romance regarding their habits more and more of the carefully verified facts have been put on record, and in this latest and most carefully prepared and edited volume, we had not only the reliable materials selected from older works, but a far step ahead by a thoroughly reliable naturalist of our own day, based on many years of personal study and intimate association with the beavers and their work. Professionally a mining engineer, the author is well qualified to appreciate and interpret the engineering feats of the beaver, but also by avocation

a naturalist he has not been misled by deceptive appearances. His interpretation of beaver houses, dams, canals, and lumbering operations are correct and conservative. If the book lacks anything in completeness it is along the lines of the more intimate habits and dispositions of the beavers, factors that have an important bearing on their domestication and cultivation as fur producers. In every way beaver-farming literature has been supplemented by it, and it gives the important general information on habits needed by those interested in raising them for fur, as well as those controlling them in the national forests and on the public domain. His omission from his list of names and type localities of one perfectly good subspecies, namely *Castor canadensis missouriensis* Bailey, was an oversight that probably no one would notice except the perpetrator of the name. On the whole the book is singularly free from errors and though brief in scope contains a vast quantity of useful information, pleasingly presented. The references in the bibliography of 64 titles to other publications on beavers enables anyone to go into the subject more extensively if desired.—VERNON BAILEY.

Patten, Bradley M. THE EMBRYOLOGY OF THE PIG. Philadelphia: P. Blakiston's Son & Co. 8vo, pp. 323, colored frontispiece, and 168 text illustrations (372 figures) of which 2 are colored. Cloth, $3.50. 1927.

This is a really great little book, written by a master of the subject who is also acquainted with cognate branches, in a style wonderfully lucid, graphic and suggestive—even the technical terms are unobtrusively explained and absorbed into the narrative and into the student's mind together. It has three natural but unindicated parts. Chapters 2 to 6, 98 pages, on the reproductive organs, sexual cycle, early development, and relation of the embryo to the maternal organism, form an absorbingly interesting story, the history of the origins, growth, movements, separations and amalgamations of a great people, the cell race. Of especial value to the early student, whom the author always particularly addresses, is the part of chapter 5 on the establishment of the organ systems. This is a rapid survey, a moving picture of embryonic development up to this still relatively simple stage and thus and admirable introduction to the study of the complex later development. Because the chick may be used more practicably up to this stage—about four days incubation—corresponding to pig embryos of about 10 mm., and because a thorough knowledge of the morphology here facilitates the understanding of the swiftly moving, interweaving ebb and flow to come, the second part, chapter 7, 34 pages, describes in detail the structure of these early mammal embryos. This is the only part of the book that approaches being a laboratory guide. The third section, chapters 8 to 13, 160 pages, gives the development of the organ systems, of bone, and of the face, jaws and teeth. The author may have treated the nervous system too briefly while seeking to avoid the other extreme, and about one-third of that chapter is devoted to adult anatomy and physiology. But the other systems are discussed in a manner that would be difficult to excel. The provoking interest of his treatment shows well in the opening paragraphs of chapter 11 on what might be termed the ecology of the embryo. "In the embryo as in the adult the main vascular channels lead to and from the centers of metabolic activity. . . . . The fact that the embryo is reliving ancestral conditions in its private amniotic aquarium renders its lungs as incapable of functioning as those of a man under water. . . . . An embryo must

solve the problem of existence during the protracted time in which it is building up a set of organs similar to those of its parents. In the absence of a dowry of stored food in the form of yolk, the mammalian embryo draws upon the uterine circulation of the mother. Utilization of this source of supplies depends on the development of a special organ which serves through foetal life and is then discarded. . . . The placenta is thus the temporary alimentary system, lung, and kidney. . . . The large size of the umbilical blood vessels to the placenta is not a surprising thing,—it is the entirely logical, the inevitable, expression of the conditions under which the embryo develops." The author writes from the laboratory for laboratory students, but as a philosophical zoologist. He would rather develop an understanding of principles and processes of growth than load the student with facts. His descriptions are seldom static but flash back and forth to link up with earlier and later stages and with the structure of other vertebrates.

The book is in no sense encyclopedic or even a complete treatise on the subject; it does not pretend to be. It is planned according to the availability of laboratory material and the author's conception of the student's needs. Notable omissions are the later development of the organs of special sense, the spleen and lymphatics, hair and hoofs. But the book should be valued for what it is, a great *teaching* work rather than a mine of information for advanced workers. Older scientists, however, who desire a fresh review of embryology or brief information on almost any point will find here a work friendly to their needs.

The illustrations are well chosen from excellent sources. But it is a pity that some of the drawings have been so greatly reduced that their details are confused and the explanatory matter is hard to read, and many others slightly trouble the eyes. The printed page is most comfortable. An excellent classified bibliography is added.—PAUL B. JOHNSON.

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NINTH ANNUAL MEETING OF THE AMERICAN SOCIETY OF MAMMALOGISTS

The ninth annual meeting of the American Society of Mammalogists was held at the Academy of Natural Sciences in Philadelphia, Pa., from April 27 to 30, 1927, with 60 members in attendance. There were 36 items upon the program, among which were several titles comprising motion pictures. The papers presented covered a wide field and in spite of the number, which was greater than last year, the schedule time of each was maintained and there was ample time for discussion.

PROGRAM

TUESDAY, APRIL 26

8:00 p.m.

Meeting of the Board of Directors at the Academy of Natural Sciences

WEDNESDAY, APRIL 27

9:15 a.m.

1. Lessons learned from intensive mammalian life history studies. W. T. Shaw.
2. Tracks in the snow. Ernest Thompson Seton.
3. Habits and distribution of the Florida water rat. Arthur H. Howell.
4. Notes on Adirondack mammals. Francis Harper.
5. Notes on a tame woodchuck. Vernon Bailey.

6. Amanita and Russula as red squirrel foods. R. T. Hatt.
7. Notes on the swimming habits of the water shrew. Hartley H. T. Jackson.

2:15 p.m.

8. Collecting mammals in Liberia. Glover M. Allen.
9. The weight of the smallest mammal. Hartley H. T. Jackson.
10. The common names of mammals. Ernest Thompson Seton.

3:30 p.m.

Annual business meeting

8:00 p.m.

11. The ways of the beaver. Norman McClintock. (motion pictures.)
12. The Smithsonian-Chrysler African Expedition. W. M. Mann. (motion pictures.)

THURSDAY, APRIL 28

9:15 a.m.

13. The placentation of primates, with a consideration of the phylogeny of the placenta. George B. Wislocki.
14. A preliminary report on the effect of pregnancy and parturition on the symphysis pubis in some rodents. A. R. Shadle.
15. Notes on the literature of the elk. T. S. Palmer.
16. Comments on the genus Synaptomys. Morris M. Green.
17. Does the opossum hibernate? Vernon Bailey.
18. A research program for mammalogists. W. B. Bell.

2:15 p.m.

19. Notes on the anatomy and habits of the narwhal. H. C. Raven. (motion pictures.)
20. Present status of the beaver. Ernest Thompson Seton.
21. Notes on the mangabey monkeys. W. H. Sheak.
22. A new method of visual education. Norman McClintock. (motion pictures.)
23. Beavers in the Palisades Interstate Park. H. H. Cleaves. (motion pictures.)
24. Growth studies on gorilla. A. H. Schultz.

7:00 p.m.

Annual dinner of the Society

FRIDAY, APRIL 29

9:15 a.m.

25. Shall we exterminate our fur-bearers? Edward A. Preble.
26. Progress in beaver culture. Vernon Bailey.
27. Photographing beavers. W. P. Harris, Jr.
28. Commercial aspects of our whale fisheries. A. Brazier Howell.
29. Hunting whales on the Pacific Coast. Canadian Government motion picture.
30. Digging up the past. Canadian Government motion picture.

31. Where the moose runs loose. Canadian Government motion picture.
32. Fossil fauna of the Siwaliks. W. D. Matthew.

2:15 p.m.

33. The question of sight in whales. Remington Kellogg.
34. The fluctuation of mammal populations in numbers. E. A. Goldman.
35. How near is the relationship of man with the chimpanzee-gorilla stock? W. K. Gregory.
36. The muskrat in Louisiana. Arthur Svihla. (Abstract presented by Vernon Bailey.)

4:30 p.m.

Final business session

SATURDAY, APRIL 30

Members assembled at the zoological park and were escorted through its collections, after which a luncheon was tendered to the society by the Zoological Society of Philadelphia.

At the business meeting officers for the ensuing year were elected as listed upon the inside cover page of this issue of the JOURNAL. Resolutions were passed extending the thanks of the society to the Academy of Natural Sciences for its many courtesies, to Doctor Stone and his local committee on arrangements, to a generous and unnamed friend who for three days bountifully provided noonday refreshments, and to the Zoological Society of Philadelphia for welcome to its gardens and entertainment of the members at luncheon.

A summary of the report of the corresponding secretary follows:

New members elected at current meeting	111
Subscribers added since last meeting	16
Total new members and subscribers	127
Present subscribers	124
Honorary member	1
Life members	31
Annual members	910
Total present membership	942
Mailing list of the JOURNAL	975
Members lost by death since last meeting[1]	4
Resignations since last meeting	26
Dropped for nonpayment of 1924 dues	16
Delinquent 1925 dues	28
Delinquent 1926 dues	29
Subscriptions cancelled during year	2
Addresses unknown[2]	9

[1] Carl E. Akeley, Henry K. Coale, Hayward Cutting, Frank M. Woodruff.

[2] Dudley S. Degroot, Harry L. Fulton, Vic. H. Housholder, Franklin H. May, Gorm Loftfield, C. E. Reno, J. B. Robinson, Kermit Roosevelt, H. R. Wells.

The JOURNAL reaches every state in the Union and a large number of foreign countries. Of those states receiving over 50 copies, 131 go to New York, 103 to California, 87 to the District of Columbia, 70 to Pennsylvania, and 52 to Massachusetts. Arkansas, Delaware, Nevada, and Tennessee each receive a single copy.

Thirteen bequest cards in favor of the society have been signed by members during the year, one of them for $5000 and the remainder for sums unstated.

The next meeting of the society will be held at the U. S. National Museum, Washington, D. C.

—*A. Brazier Howell.*

COMMENT AND NEWS

The Abyssinian Expedition of the Field Museum, under the leadership of Dr. W. H. Osgood, has returned with a large collection including 1400 mammals and 2000 birds. L. A. Fuertes, ornithologist and artist of the expedition, although devoted mainly to birds, made a number of colored studies of mammals. Other members of the expedition were James E. Baum, Jr., Suydam Cutting, and Alfred M. Bailey. Among the larger mammals obtained were the so-called mountain nyala (*Tragelaphus buxtoni*), the rare Abyssinian ibex (*Capra walie*), and the Abyssinian wolf (*Canis simensis*). Small mammals include a number of new forms and at least one new genus, a sort of water rat, the first markedly aquatic rodent to be discovered on the African continent.

H. E. Anthony, Curator of Mammals of the World of the American Museum of Natural History, returned on June 14 from a six months' expedition in the Anglo-Egyptian Sudan. Mr. Anthony left New York in December, 1926, and was accompanied by Irving K. Taylor who financed the expedition. This was Mr. Taylor's fourth trip into the Sudan and on this occasion he wished to contribute all the results of his shooting trip to the American Museum. The party covered, roughly, about 4,000 miles in the Sudan, operating out of Khartoum as a base. By means of native sailing craft and river steamer, hunting was done at scattered localities as far south as Mongalla. At the conclusion of the work along the banks of the Nile, Taylor and Anthony moved over into the Red Sea Hills to hunt ibex. This trip was made on camels across an arid desert area.

The major results of the expedition are a good series of many of the large game mammals, such as buffalo, roan, hartebeeste, tiang, waterbuck, kob, ibex, and gazelle. Collections were also made of birds, fishes, and reptiles. Both motion pictures and still were taken, but owing to the extended itinerary and the short time spent at each place, the photographic results were necessarily rather limited.

The "celluloid" hippopotamus projected some months ago by Leon L. Walters of the Field Museum has recently been completed and placed on exhibition in the Stanley Field Hall, near Carl Akeley's African elephants. The work has proved highly successful, both the translucent color effects about the head and the fine detail of the skin surface being reproduced with a realism scarcely approached by

other methods. The material used is not celluloid, strictly speaking, but a preparation of cellulose acetate which, heretofore, has been used only for the reproduction of relatively small reptiles and amphibians. It now appears that it is quite suitable for the reproduction of all the large naked or thinly haired mammals, and the Field Museum now proposes to have Mr. Walters employ it for the Indian, the black, and the white rhinoceros.

The California Fish and Game Commission is making an extensive survey preliminary to the taking of a census of the seals and sea-lions on the entire coast of California. Deputy warden Paul Bonnot is in charge of the work, and will study the habits and food of these mammals as well as check on their distribution and abundance.

Edmund Heller, after two years' work for the Field Museum in central Africa, has again severed his connection with that institution and is planning to devote himself for a time to lecturing and writing.

Olaus J. Murie, of the U. S. Biological Survey, has been assigned field head quarters at Jackson, Wyoming, where he will make detailed investigations of the habits and life history of the elk. Mr. Murie was formerly stationed at Fairbanks, Alaska, from which place he studied the barren-ground caribou.